EA-87-02

Ontario

ENVIRONMENTAL ASSESSMENT BOARD

VOLUME: 72

DATE: Wednesday, February 15th, 1989

BEFORE: M.I. JEFFERY, Q.C., Chairman

E. MARTEL, Member

A. KOVEN, Member

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EA-87-02

HEARING ON THE PROPOSAL BY THE MINISTRY OF NATURAL RESOURCES FOR A CLASS ENVIRONMENTAL ASSESSMENT FOR TIMBER MANAGEMENT ON CROWN LANDS IN ONTARIO

IN THE MATTER of the Environmental Assessment Act, R.S.O. 1980, c.140;

- and -

IN THE MATTER of the Class Environmental Assessment for Timber Management on Crown Lands in Ontario;

- and -

IN THE MATTER of an Order-in-Council (O.C. 2449/87) authorizing the Environmental Assessment Board to administer a funding program, in connection with the environmental assessment hearing with respect to the Timber Management Class Environmental Assessment, and to distribute funds to qualified participants.

Hearing held at the Ramada Prince Arthur Hotel, 17 North Cumberland St., Thunder Bay, Ontario, on Wednesday, February 15th, 1989, commencing at 9:00 a.m.

VOLUME 72

BEFORE:

MR. MICHAEL I. JEFFERY, Q.C.	Chairman
MR. ELIE MARTEL	Member
MRS. ANNE KOVEN	Member

Farr & Associates Reporting, Inc.

A P P E A R A N C E S

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----Upon commencing at 9:00 a.m.

THE CHAIRMAN: Good morning. Be seated, please.

Welcome back, Mr. Armson.

MR. ARMSON: Thank you, Mr. Chairman.

THE CHAIRMAN: You are still under oath, so we do not have to bother swearing you again.

MR. ARMSON: Yes, I understand.

KENNETH ARMSON, Recalled

THE CHAIRMAN: Mr. Freidin?

MR. FREIDIN: Mr. Chairman, perhaps if I could just take a few moments and take the Board through the executive summary for this particular panel.

As has been -- I wish, I've got to move the post here - as has been indicated by other witnesses and repeated by me a number of times, one of the important messages throughout the entire evidence that the Ministry is attempting to make is that the practices which constitute timber management are indeed very inter-related and are planned in contemplation and with knowledge of the effect one practice can have on the next.

If you look at paragraph 4 of the executive summary, you will note that the statement is

made that:

"Intervention in a forest, whether from natural forces or humans will have certain effects."

And as is indicated later in the executive summary:

"The benchmark against which the Ministry believes that an assessment should be made as to whether the effects of timber management activities on the environment is significant or not is to assess those effects or potential effects against the type of effects which would occur through disturbance in the natural forest, disturbance caused by natural means."

And as a result of that, in paragraph 4 those subject matters are going to be dealt with because they will provide the basics to not only understand the benchmark argument in theory, but to have some appreciation of what that benchmark is in reality will require an understanding of those subject matters referred to in paragraph No. 4, and that's necessary so that a comparison can be made where necessary.

There are certain physical and biological concepts and processes which are ongoing in the forest, and Mr. Armson will deal with those.

Forest dynamics in paragraph 6. Forests are not static, you have heard that before. Mr. Armson, in Panel No. 2, indicated and described the major natural disturbances of fire, wind, insects and disease. We are not going to repeat that evidence, but Mr. Armson will be building on that somewhat.

Over on page No. 2 there is reference to succession and the point will be made in this evidence that just as the community of plants change in the forest in a natural state and through natural disturbance, so does that occur as a result of timber management activities.

The submission will be that intervention by man does in fact have similar effects to those caused by natural disturbance, that there may be certain differences but that those differences are not significant in terms of adverse effects on the forest estate.

Mr. Armson -- I say effects on the forest estate because that is what Mr. Armson is going to be dealing with, and we will be relying on the evidence of witnesses in Panels 10 through 14 to speak to what the effect of these practices may be on non-timber values.

Now, that doesn't mean, Mr Chairman, that Panels 10 through 14 will not be talking about the

potential effects of timber management activities on the forest estate. For instance, in Panel No. 10, Mr. Greenwood will take and build upon the general evidence given by Mr. Armson in this panel and he will, for instance, be speaking about the actual activities of timber management themselves and he will give evidence linking those specific practices to specific potential effects.

An example being, Mr. Armson will describe in general terms why -- what disturbance of the forest floor is and what effect that can have on the nutrient cycle.

Mr. Greenwood in Panel No. 10 will be describing specific timber management activities of harvest which have the potential to disturb that forest floor and will be indicating the measures taken by the Ministry and the forest industry to ensure that those effects remain potential and don't occur in fact.

In panel -- pardon me, in paragraphs 9 and 10, there is reference to the forest as a production system. You will note that the main components there are water, air and nutrients. Those particular raw materials are converted into organic compounds by means of solar energy. Those processes are highly temperature-dependent and they are also

affected by certain local site characteristics.

Mr. Armson will be describing those processes and the importance of that, again, is that it is related to the benchmark that I referred to being the results of natural disturbance.

The concepts in paragraphs 9 and 10 outline the basic understanding that, in my submission, we should all have about these processes within the forest before we get into a discussion of specific activities and specific potential effects.

You will see that the hydrologic cycle is dealt with at pages 11 through 14, and I won't take any time now to deal with that. You will see that the nutrient cycle is dealt with in paragraphs 15 through 17.

Mr. Armson will be describing that nutrient cycle to you. And in both the case of the hydrologic cycle and the nutrient cycle, the way we are going to approach that is to describe how those cycles work through nature without any disturbance. We will then describe how that cycle can be affected by natural disturbance and we will then describe how that cycle can be affected through man-made disturbance.

In terms of the nutrient cycle, a lot of the discussion I think will be revolving around the

subject of full-tree harvesting. Mr. Armson will describe that very briefly, it is a subject -- logging methods is the subject of one of the papers in Panel No. 10, it is a paper to be presented by Mr. Oldford. But to deal with the nutrient cycle more fully, which was one of the prime intentions of moving parts of Panel 10 back into Panel 9, Mr. Armson will be addressing that matter of full-tree harvesting.

Assessing the significance of change. Paragraph 18 is the benchmark issue. I would just point out, Mr. Chairman, that no issue was taken with the position of the Ministry in relation to that matter and we don't intend to deal with that at any length. Mr. Armson will, however, address that matter.

The last point I would like to make about the material from Panel 9 is that, in my submission, it is important to have an understanding that in assessing the effects, or perhaps more accurately the potential effects on the forest estate by disturbance, whether naturally or by man, that the magnitude, the frequency, the intensity and duration of those effects is important in assessing the significance of those effects.

If I can repeat those again; those are: the magnitude, the frequency, the intensity and the

duration of those effects are important concepts to keep in mind.

As I indicated yesterday, Mr. Armson will, after dealing with the Panel 9 material, address the answer to the undertaking which was given in Panel No. 4 to Forests for Tomorrow dealing with the subject of clearcuts and that evidence is designed to address issues which arise from concerns -- some concerns in certain quarters about the size and the effect of clearcuts.

Now, Mr. Armson -- Mr. Chairman, I don't know whether the witness statement has been made an exhibit.

THE CHAIRMAN: I don't believe it has.

MR. FREIDIN: Can you just reserve an exhibit number for that, Mr. Chairman, I don't have a copy here right now.

THE CHAIRMAN: This will be Exhibit 414.

---EXHIBIT NO. 414: Witness Statement of Panel No. 9.

DIRECT EXAMINATION BY MR. FREIDIN:

Q. Now, Mr. Armson, in going through your paper it appears that in many respects it is very technical in nature. Is that a characterization that you would agree with?

A. To some degree, yes.

Q. And in preparing that paper, did you consider whether in fact it was necessary to deal with the various topics set out in the report in as detailed a manner from a scientific or technical aspect?

A. Yes. I believe, however, that these matters which may be mainly -- primarily scientific and technical can be explained in relatively non-jargon language that most would understand.

Q. Is there any general reason that you have dealt with certain topics in a technical way nonetheless?

A. Yes. In the evidence I have made the point that the forest is dependent on basically three broad groups of factors. I think the air, obviously, nutrients and water and that in looking at the growth of forests, at the factors which affect that growth, inevitably you are looking at those elements.

The air, obviously we have very little control of certainly in terms of the forest region, but in terms of both nutrient supply and water, we are dealing perhaps not with the basic supply, but the manner in which the forest itself or activities, particularly timber activities, may affect the forest and the soil, how they can impact or impinge on the supply of both nutrients and water.

Q. And a very basic question: What is the role or the important role that water and nutrients play in the forest estate?

A. They are vital for the growth of forests and the biological activities that take place.

Q. Are there any structural concepts that, in your view, the Board should keep in mind when they are considering either the nutrient cycle or the hydrologic cycle?

A. Yes, there are. In terms of the nutrient cycle, the scientific concepts which I think are readily understandable, are that within the soil forest system there are essentially two ways in which -- or locations, if you will, in which nutrients can occur.

They can occur either in pools; that is, as elements within some major component. We would talk about, for example, the forest pool which is all the pool of nutrients within the forest itself, or the pool of nutrients within the organic body of the soil or within the mineral component of the soil.

And we can then go on and define how it occurs there, but we speak of those as pools and they have essentially three characteristics: They are relatively large - you can remove a forest but you are

removing, then we would say, a pool - they are relatively static, and I would emphasize the word static. The soil, for example, when we look at it today, tomorrow and the next month remains visibly in many respects much the same, so the elements are there.

And what is, I think, most important about those pools is that the form of the element; that is -- and the nature in which it occurs, whether it occurs as part of a mineral, as part of a rock, or whether it occurs as part of an organic compound, and the location within that pool become quite important particularly when we look at tree growth or other aspects of the forest in relation to those pools.

The other element, if you can envisage theses pools, are the interchanges; the flow that takes place from one or more pools to another.

Give an example: In a hardwood forest or with deciduous trees we can talk about the pool in the foliage; comes the fall, the leaves fall to the ground, the leaves become part of the forest floor and that becomes therefore -- that component becomes part of another pool. That's a very simple way.

But there are in fact other transfers going on. Elements are leached from the foliage to the soil, and we talk about those elements that are moving

from one pool to another as fluxes and those fluxes -- and they are fluxes within the soil. The weathering, for example, of a mineral soil particle under normal natural conditions results in certain chemical changes whereby a calcium as an element becomes, if you like, loosened up from the rigid structure as a mineral compound and becomes available in the solution, the water in the soil.

And those fluxes are characterized by differences in concentration. You could have, for example, a high concentration of an element moving in the flux, often usually in a watering solution; they are constantly changing as compared with the pools, they are in a state of movement; and to a very large degree, they are dependent on the conditions which they occur primarily within the soil and, of course, they are temperature-dependent.

Those characteristics I think are quite important and should be kept in mind. If I may, Mr. Chairman, I have a slide which just summarizes that.

Q. Just before you perhaps show that, can you advise whether the description you just gave about the pool and the fluxes, is that evidence applicable to both of the cycles, the nutrient and the hydrologic, or only to one?

A. We speak of these pools and fluxes primarily in relation to nutrients because I think, as the Board will understand in terms of water, it is in a constant state of flow normally unless it is frozen, so we tend not to look at that in terms of pools and fluxes. We do look at amounts that are stored within the soil, it's true, but it usually is in a state of movement of one kind or another.

Just then briefly to summarize --

MR. FREIDIN: Mr. Chairman, I have copies of this particular overhead. Mr. Armson will be speaking to each of them, but I could make them available if...

THE CHAIRMAN: Well, you might as well have it I think as part of the record.

MR. FREIDIN: All right.

MS. SWENARCHUK: Can you come forward with it?

MR. FREIDIN: I think most of the overheads are going to be out of the materials. There has been a couple of them that have been prepared like this which have not.

Maybe we can mark this as an exhibit, Mr. Chairman.

THE CHAIRMAN: Okay. Exhibit 415.

---<u>EXHIBIT NO. 415</u>: Overhead.

MR. FREIDIN: Okay. If you would like to proceed, Mr. Armson.

MR. ARMSON: Just to recapitulate briefly, Mr. Chairman. I have emphasized here the three attributes of the pools, the fact that they are normally prepared in relatively large amounts, the amount within the soil, the amount within the vegetation, for example, they are relatively - and as I say, I emphasize the relatively aspects -- relatively static. They are changing.

Sometimes they can change very dramatically, but we tend to view them as temporary, not static, but more that way. And the form, nature and location become extremely important; where are they - and just think of this very simply - where are they in relation to the root system of the vegetation.

If you have a lot of nutrients and the plants are in a position where the roots can't absorb it either for physical or other reasons, then there is not much use to the plants.

Can you hear me?

THE REPORTER: Yes.

MR. ARMSON: In terms of the fluxes, as I said the concentration and the rate of movement become

important. A simple example: If a plant in growing has a certain need for nitrogen, phosphorus, whatever, and that needs to be expressed in terms of the demand, a rate, leaves are unfolding, they are growing. If they are going to unfold and become normal shape and size it needs so much nitrogen.

If the root system, which is in the soil, is absorbing nitrogen but for whatever reasons the rate at which that root system can absorb it is not equal to the rate which the plant is demanding it, then you have an imbalance and a stress occurring. So the rate can become extremely important. If the plant's rate of need is low and the flux is low, then they may be quite well imbalanced.

We would say -- you might say: Well, there is a very low rate of supply, but if the need is not high or higher than that, then there is not a problem.

It is a dynamic situation, it is changing, changing ove rtime, sometimes very rapidly, and as I indicated, it is dependent on many factors, a large number of which are associated with the soil because this is where the root systems are in absorbing nutrients and also temperature-dependent, not only because of the fact that the chemical processes of

weathering are temperature-dependent, but because much of the biological activity in these pools, in the soil for example, in the decomposition of organic material and the release of nutrients, those organisms are also -- their activity is temperature-dependent.

When we attempt to measure the size of the pools and the flows between pools, one of the ways we usually look at it is in terms of inputs; what is coming into the pools and what is being lost from them, and this poses some very difficult questions.

The inputs, for example, can be seen - and I will show some illustrations of this - as coming basically from the atmosphere and also from the weathering, bringing up from lower geological materials up from the top. That's one way of looking at it. But we get into the problem in trying to measure that of determining absolute amounts that may be there but it may not be the absolute amount, you could have a lot of something, but the amount that can be weathered or is available becomes much more critical.

The rates of those transfers, therefore, become extremely important and that is where we have a lot of difficulty in quantifying that. We can often look at it, look at situations and from certain definitive measures then make some -- I would say,

deduce some possibilities about the relative amounts between absolute levels knowing other factors, but it is very difficult to quantify all the elements and the rates within this, and I will say more about that.

MR. FREIDIN: Q. And just one question before you go on. You say that there may be difficulty in measuring the absolute number and it may be that the amount available was an important factor. What's the difference between this absolute number and the amount available?

A. Well, we could, for example, measure the total amount of nitrogen in the forest floor, the surface organic layers, and that may be "x" number of tonnes per hectare, we can do that. But in fact in terms of a plant or another organism there that is dependent on nitrogen, most of that nitrogen, virtually all of it, may be unavailable; it may be in a form that the plant cannot absorb.

In other words, if the nitrogen is tied up in proteins, in organic material and they are not broken down, they are not decomposed, then an organism, a plant, a young seedling or vegetation may in fact be rooted in a large amount of nitrogen and suffer very severe deficiency of nitrogen.

Again, I want to finally emphasize the

matter of looking at forest vegetation, any kind of vegetation and looking at nutrient supply in terms of demand and availability. And here we have to take into account that the needs or the demands are changing over time, they are changing not only within a growing season. For example, as a tree is making its major height growth - usually for conifers early in the season, June, maybe early July - there is an extension of the tree, there are new needles that are being extended and so forth. That is when the demand is highest. It will be growing certainly through the balance of the season. We have a very high demand early in the season.

Now, nutrient supply, water supply can become very critical at that time. Also, as a tree increases in size or as vegetation increases, we can make the point in general. The crown -- the tree vegetation not only increases in size, it increases its amount of foliage, it expands its crown, we would say, and as it does that, it is increasing its demand. So that over time as a young forest grows, we see it increasing its demand for nutrients and also for water.

If we look at a particular given forest system, the soil -- physical soil does not change dramatically over a matter of time, not unless there is

some major disturbance and by that I mean a catastrophe. It is a sand plane -- it's a sand plane, clay area.

The forest floor changes over time, changes over decades, there is an addition of litter on them. So that when we look at the forest or the area of vegetation at one instant in time, if find we one that is five years old, the demands -- the relative supply and demands are quite different than if one were to look at them in terms of that same stand when it is 30 years old, 40 years old, 60 years old and so on.

So there is a progression. So that if we say: What is the nutrient supply and capacity of a soil at any time, if we are looking at it in terms of timber management, we look at it in terms of the state of the vegetation at that time and what it will become.

And that is what I am referring to here in terms of the rates of demand and supply and one can look at those again in terms of both an absolute and a relative measure.

Q. Now, Mr. Armson, you used two terms in your last point that you made - and I don't want to get too far ahead because I know you are going to be dealing with them - but perhaps, you used the term forest floor and you also spoke about the addition of

litter.

Perhaps you could just sort of, in a very brief way, describe what you are talking about there and we will deal with it perhaps in more detail later?

A. Yes. The forest floor is the surface organic accumulation that occurs in forests and it comprises normally the material that comes from the vegetation itself which we call the litter, the leaves that come down in the fall or during the year, branches, twigs, anything in fact that arrives at the surface of the soil we term litter, maybe from lesser vegetation.

That material undergoes some degree of decomposition. It may be very little or it may be a large amount, but it is on the surface of the soil and that is that forest floor.

Sometimes, Mr. Chairman, you will hear, and perhaps have heard in previous panels, reference to the word used called duff, d-u-f-f, and foresters commonly talk about the duff. What they are talking about is actually the forest floor.

Q. Okay.

MR. MARTEL: I can't find it in the dictionary, I looked.

MR. ARMSON: I think, if I may, Mr.

Chairman, the forest floor is a much more accurate term. Something you walk on on the surface of the soil.

MR. FREIDIN: Q. Now, Mr. Armson, can you tell me are the pools -- all right, let's deal with this one first.

MR. ARMSON: Mr. Chairman, this is an overhead but it is the same although it is coloured, it is the same that is in the evidence package, I think it is Figure...

MR. FREIDIN: Q. Figure 10, I think at page 46?

A. What I have attempted to do here is to portray, in a schematic way, the pools that one would normally associate with a forest and to indicate the kinds of -- I shouldn't say kinds, but the movements or the fluxes that can occur between those pools in the forest.

I mentioned that the input -- the major source of input is atmospheric. This is sometimes not appreciated - perhaps sometimes it is appreciated to too great a degree in urban areas - but in the forest, in the boreal forest there is continually through -- via the rainfall, a considerable input of certain nutrients.

One of the ones is nitrogen and it is associated primarily with electrical storms. Nitrogen compounds are created and reach the surface of the earth via the rainfall and that is one of the key inputs and that can amount -- and it varies depending upon the location within the world, but it is something of the order of 10 to 20 kilograms per hectare or roughly something about the same amount in pounds per acre.

The bulk of the nutrients, however, are held in the soil pool which I indicated on the left of Figure 13 at the bottom. In the slide it is coloured brown, but it is to the left and that is, I think, where we commonly would say that is the source of the nutrients for the plant that is growing.

The nutrients within that and I won't describe the -- within the evidence there is a listing of those elements that are required as essential, some are required in larger quantities than others, but the plants in this case schematically shown in the case of the forest there is a tree, an understorey, there is an uptake. Plants absorb nutrients, so there is a flux; there is a movement of nitrogen, phosphorus, calcium, potassium, magnesium and so on down the line via the root systems primarily and taken up by the trees and

enter into the physiological process as it grows.

Now, once within the tree there are two things that can happen to it: It can either remain and in fact many of those elements will be recycled within the tree. Nitrogen can move from an older tissue to a younger tissue. This commonly happens in most of our forest species, certainly the conifers. Nitrogen from three-year old needles will be translocated, moved back into buds and bud tissue and then becomes in fact supply.

So there is a recycling going on within the organism. This even happens in hardwoods and when leaves are yellow -- the different colours in the fall, part of that is due to the movement out of nutrients, certain nutrients from the foliage, let's say, the maple tree into the twigs and bud tissue.

Some of those nutrients will not be recycled but will be returned via litter, which is the most obvious one, but there are two other ways that nutrients are lost from that vegetation pool, the tree. It can be washed out of the tissues that are exposed to the air and to precipitation. If it is washed out of the foliage, and certain elements are very susceptible to this, then we talk about it as crown wash or throughfall.

In other words, it is just as if you had a rag with -- a moist rag with certain chemical elements in it and you put it under a showerhead and underneath the rag if you were to put a bottle catch it, we would say we are washing out some of the elements out of that rag. Potassium is an element that is noted for this. It is an element that does not normally occur in an uncombined -- doesn't enter into the tissues of plants, it is there usually in a free form and be readily washed out.

Another way in which we have return is stemflow. Water comes down the bark -- the bark of most trees has higher concentrations, much higher concentrations of nutrients than the wood and that can be due to the -- so there is a return to the forest floor and to the soil from the forest, both in the form of litter, but also to a lesser extent in the form of stemflow and crown wash.

Now, there is just a point that I would make here in terms of the form - and here we are speaking of physical form. The water that contains the nutrients, particularly in stemflow, flows down the stem and then along the root system into the soil. So that it is a very direct and rapid feed, if you like, to the other -- to the point of the plant which is

absorbing the nutrients. Whereas when it comes down in the form of litter, it has to go through usually a rather complicated set of decomposition processes.

This similar type of uptake is, of course, going on for other vegetation other than the tree vegetation, the understorey vegetation, mosses, all of those organisms are absorbing from the soil or from the forest floor itself which would be the case of the mosses -- in many of the mosses and, again, it would be recycled within that understorey vegetation.

One of the characteristics of the pools, if you like, of the understorey is that in most forests that is a minor pool compared to that which is in the forest itself. But in certain conditions, when a forest breaks up under natural causes or when there are disturbances which allow for -- for example, by the removal of the forest cover by what means - one means or another - that understorey vegetation can be very significant usually for a short time and I would -- and we will return to this, but one example would be the very lush and luxurious growth that can occur in the understorey after a fire.

We recognize that as one of the characteristics of that major disturbance is a very lush growth of the understorey and subsequent forest

redevelopment. So we have an uptake and we have a return again in the form of litter primarily. And from the forest floor we have movement to the soil pool again where many of the processes of weathering and so on take place.

Q. Now, Mr. Armson, you refer to the understorey. Could you describe in general terms what you mean by understorey?

A. The understorey comprises the vegetation which is not part of the forest vegetation, it is not part of the woody species, the tree species. It therefore comprises mosses, herbs, herbacious layer, shrubs and indeed often in many -- in a young forest it may -- in many young seedlings of tree species. One could have in the understorey young balsam fir, young pine and so on.

Q. Is part of the understorey woody?

A. Yes. Oh, yes. In our forests the largest component in most instances would be woody; mountain maple shrubs, hazel. These would be shrubs that normally are of the order -- height growth, grow to a height of -- alder would be another one, woody alder would grow to a height of four, five, six or eight feet.

If I may, Mr. Chairman, they are the type

of thing that when you are walking through the forest make you mad.

Q. And non-woody shrubs; blueberry, raspberry they are part of the understorey?

A. They are part of the understorey.

Q. Okay. Can you advise, are these pools and the fluxes between pools the same in forests everywhere?

A. No.

Q. Could you explain sort of the major differences that would exist?

A. Well, the major difference that would exist would be, for example, species. If you have a conifer species which retains its foliage, then the pool size will be different with respect to not only the fact that it is a conifer versus a deciduous tree - and there are obvious differences there - but even within conifers or within hardwoods there are differences in terms of the pool size for trees of the same size.

In other words, what I am saying is this: If one were to take a maple tree of a certain size or balsam fir and one were to look at the concentration of nutrients, of certain nutrients within it one would find -- we find that there are certain species which

tend to have larger concentrations of certain nutrients or nutrients generally than others.

I have an overhead which is I believe from Panel 10 that will illustrate this and this is...

Q. Page 224.

A. 224.

THE CHAIRMAN: Mr. Freidin, are we going to exhibit Panel 10's witness statement at this time?

MR. FREIDIN: Perhaps you could reserve a number for those as well. I don't have a clean copy.

THE CHAIRMAN: Okay. Panel 10, Volume I can be Exhibit 416A, and Panel 10, Volume II can be 416B.

MR. FREIDIN: 416?

---EXHIBIT NO. 416A: Witness Statement for Panel 10, Volume I.

---EXHIBIT NO. 416B: Witness Statement for Panel 10, Volume II.

MR. FREIDIN: Q. I think you were talking about these pools and fluxes being different depending on species.

A. Yes. In terms of species, Mr. Chairman, the figure that you have from page 224 in Panel 10's evidence shows a series of histograms for a number of species; aspen, balsam fir, red mapel, red pine, white birch, white pine and white spruce.

And each of the five sets of histograms there are for a different element and the one on the top left that I have on the screen is for calcium, one on the top right is magnesium, the one in the middle on the left is for potassium - that was the element that I referred to earlier as being present normally in very uncombined form and, therefore, subject to movement - and the one to the middle at the right is for phosphorus, and at the bottom, one for nitrogen.

And this is merely to illustrate that those different species, in terms of the amounts which are measured on the vertical axis which is the concentration here in milligrams per gram, that you will notice that there are certain species in terms of calcium, for example balsam fir and aspen, and to the right white spruce, tend to have higher concentrations.

And if you look at each one of those sets of graphs for the five elements you will see that for four of them; for the calcium, for the magnesium, for the potassium, and the phosphorus, although they are not identical, there tends to be a pattern with aspen and balsam fir and white spruce tending to have the higher concentrations.

With nitrogen it is a little different with --but again balsam fir shows that. And this is

what I mean, we could go on through a number of species and you could say: Well, it all depends on where they are growing and so on. But those general characteristics and, very generally, we think of hardwood species, deciduous species as having higher demands generally than I think as was evidenced here by aspen in particular, a higher demand; white birch inbetween and so on, and conifers tending to be lower, but there are many many differences.

We know, for example that white cedar has a very high requirement for calcium. So it is just to point out that there are these species differences.

Q. All right. And just leave that on for a second. We will revisit this I guess a little later on in your evidence.

A. Yes.

Q. And as we look at that particular figure from page 224, it indicates the concentrations in these various species. Can you make any direct linkages in terms of demand? In other words, you have one there that has a high demand in one of those nutrients. Does that means it has a high demand for that has well?

A. We would infer from this that the demands would be higher. Yes, we would infer that.

Q. Okay, thank you. Now, still sticking with the pools and the fluxes between pools, you have now just -- you have indicated how the pools can be different in terms of the pool which is represented by the tree itself.

Can you advise me whether the pools and the fluxes between pools - and we are talking about nutrients - is different or whether it is the same in all parts of the world; forests in all parts of the world?

A. No, it will not -- if I can answer that in this way: We talked about vegetation which is really the demand side, there are differences there.

But soils are different; in other words, the nature and amounts of nutrients within the soil can be quite different depending on the type of soil whether it be, for example, a clay of a certain type, whether it be a sand - and not only that, because those descriptions refer only to particle sizes - the nature of the minerals within either clay or sand, so on, those are important factors.

So we can have soils which, because of the geological origin, may be very high in calcium or they may be very high in phosphorus because of the minerals which occur in those rocks. Now, that doesn't

necessarily mean because they are high in them in terms of an absolute sense that they may be high also in the supply sense. We often anticipate that or we look for that, but it doesn't necessarily follow. So the nature of the soils.

The third factor would be - and this you referred to earlier, Mr. Freidin - and that is the climate and that affects it in two ways. First of all, I referred to atmospheric input. In certain regions of the world, the atmospheric input either as a result of natural phenomena - and I referred to lightening storms and so on - or to the occurrence of particulate dust particles in the soil -- in the atmosphere, these can be sources of input; in other regions of the world they may be relatively minor.

But more specifically, in terms of other regions of the world, we are looking at temperature and moisture factors which can control or influence very dramatically the rates of other biological activities. The decomposition, for example, of the forest floor.

An example of that would be where we, in the area of the undertaking, talk about the forest floor as what we commonly see. There are areas in the world under forest where a forest floor virtually does not exist. In other words, the litter as soon as it

reaches the surface of the earth is virtually decomposed, in fact it is often decomposed before it hits the ground and these would be in subtropical and tropical areas where the pool size within the soil system and, more particularly, the forest floor is very very minimal. And the implication of this is, of course, that the fluxes are normally very, very rapid there so that anything that interferes can be quite significant there as compared to an area where you have a large pool size and a relatively lower flux.

Q. Does the fact that you have changes -- I am sorry, if I interrupted you.

A. I was just going to say -- add to this that, there I have been referring to the effect of temperature and moisture on decompostion of organic material changing in fact the pool size of the forest floor, but the temperature and moisture regimes within different climatic areas also affects the weathering of the inorganic, the mineral soil particles.

So that, again, with the same pool size, if you will, with the same material in a climate of relatively low temperature or periods of -- major periods of low temperature and so on the rates of chemical weathering will be much less and, therefore, the fluxes will be much lower.

Q. The forests that we are talking about usually experience a winter period as opposed to forests in many other parts of the world. Does that fact have anything to do, or any connection with nutrients and, perhaps more generally, productivity of the site and natural renewal?

A. Yes, it does. Where you have high rates of flux and low pool sizes, as in warmer climates, the rates of growth of the vegetation are normally correspondingly greater. Anything that interferes with the flux, a disturbance which disrupts, if you will, that movement then can have a very major impact; whereas in areas where we are looking at nutrient cycles where you have considerable bodies of reserves of nutrients in pool sizes, particularly in the organic areas, forest floor in particular, there the impact of a disturbance - it can be great and significant - but by and large the fluxes are low and the impact of a disturbance there, although variable, it can be positive, negative or have very little, but the tendency there is for it to be buffered, the system is buffered.

In other words, if you take all of the vegetation away from a soil with no forest floor and so you have only the residual soil - and in many of these

areas they are old soils, been highly weathered, they do not have a high level of the fertility - when you remove all the vegetation and just leave it, then you have a relatively infertile situation.

If you remove vegetation from a soil where you have a forest floor, a relatively young soil, the weathering has not gone on - partly because it is young, partly because the periods of temperature and moisture have not been conducive to - you have a large body of reserve and although the rate may be relatively low, there is a large body of nutrients held there.

And that is the situation which we have fortunately in most of the northern hemisphere and certainly within the area of the undertaking.

I think perhaps as an analogy I might use this one: If you had a series of investments and you had investments which were bringing very high rates of return on a daily basis and something happens to them, then your cashflow is sort of gone. If you have a large amount of inherited bonds at 4 or 5 per cent, you can lose a certain amount of that, the rate of flow is much lower, but you have still got the capital and it isn't producing very much but it is producing something.

I think if the Board takes that analogy.

We are looking really at rates and we are looking -- which could be an analogy to interest, and we are looking at capital and we are looking at how that affects your -- I guess I would say, your state of well-being in a financial way.

Q. And I just want to make it clear or have it clear, Mr. Armson, which type of situation in terms of these nutrients and these pool sizes and flux exist in the boreal and the Great Lakes/St. Lawrence forest that we are dealing with in this undertaking?

Are they an area which has, as you indicated in one -- you said considerable body of reserves?

A. Yes.

Q. Where does it fit into the analogy that you use in terms of the banking?

A. It fits in with a rather large estate inherited which has a relatively low return rate, rate of investment in terms of the soil which is young, which is not severely weathered chemically, that is, it has investments in the forms of forest floor, which are partially decomposed which change their -- can change their rates of decomposition depending on various types of disturbance, but in fact are there.

And it also has, if I may say, when we

remove the forest pool, the tree pool there is, in most instances, a smaller but significant pool in terms of lesser vegetation which exists there and which may in fact increase in size once the other is removed.

Q. All right. And we will be talking about that particular situation where you remove the tree pool later on in your evidence?

A. That's correct.

Q. Now, using the analogy, if you wish, the forests in the area of the undertaking, where do they fit in in terms of their ability to recover or to withstand disturbance and continue to be productive?

A. The forests in the area of the undertaking, the vegetation, but more particularly the commercial tree species, are species which are essentially adapted, biologically well adapted to regrow either from seeds or by vegetatively after major disturbances, whether they be natural - and that is normally held the species obviously evolved under those conditions - but also with respect to the major disturbances that we may bring about in the forest; that is, by the removal, for example, of the trees, total removal of those trees.

Q. One moment, please. And what about the ability of the forest in the area of the

undertaking to recover from those kind of disturbances?

A. Our forest -- I am sorry if I -- these species are adapted to recover, to regrow, as I say, either from seed or from vegetative growth and reoccupy the area. One may not necessarily be the same species that was there before, but that is consistent.

And if the Board will recall in -- I believe it was Panel 3, the evidence from Survey of Artificially Regenerated Areas indicated that the regrowth of commercial tree species was a common feature.

Q. Now, in Panel No. 2, Mr. Armson, you spoke of the dynamic agents of change, both natural and man-made, and this perhaps may be a bit of a -- cause you to repeat a little bit of your evidence or perhaps summarize it, but with those dynamic agents of change aside - let's just put them aside for the moment - are there things which can affect this nutrient cycle that you have referred to?

A. Yes. I have indicated, for example, that the rates of decomposition are a key factor. If there is a relatively high - and I don't by that mean all the litter is decomposed rapidly within one year - but if the rates of decomposition are higher, or if they become higher because of some change in

temperature or moisture relations, then the flux of nutrients will change. It will normally -- the supply of what we would term available nutrients would go up.

The nature of the organic material itself is important. If, by whatever circumstance, the species changes - and it does normally by successional - normal in a forest area that is not necessarily disturbed area, there is a change, both in the nature and the amount. As the species change within that, that may change and normally it does change to some degree the level of, or the state of the flux for various nutrients.

I mentioned the temperature which affects it and the moisture obviously, these are factors and the timeframe over which this occurs is a critical factor. That if there are only short periods when temperature and moisture are suitable for more rapid decomposition, then there will be less decomposition.

These are all factors that are in many ways inter-related but can affect the amount and availability of nutrients in any given situation.

Q. All right. And in terms of the pool constituted by the forest floor, you indicated that it decomposes?

A. Yes.

Q. And is there a relationship between temperature at the forest floor and that decomposition?

A. Yes, there is. Well, temperature and moisture; because decomposition is dependent on those two factors, insofar as they affect the activities of the micro-organisms which bring decomposition about, I would suggest to you it is a very much like a compost pile. If you have suitable moisture and temperature and, of course, a supply of nutrients to the micro-organisms themselves, then they will perform the function of composting or rendering litter in effect into humus much more rapidly than if it is in a situation where it is either dry or dry and cold. So that those temperature effects are key ones.

And I would suggest to you also that when there are disturbances, whether they be natural or man-made, one of the effects often by -- if those disturbances result in removing vegetation, is to change the temperature and moisture relations particularly in the forest floor and, therefore, the decomposition.

Q. Thank you. Mr. Armson, do all foresters understand the principles about pools and fluxes that you have just described?

A. Well, in their university education

it is normal for them to be exposed to it in a course on forest soils. How much they retain afterwards is another matter, but they are certainly exposed to it, yes.

THE CHAIRMAN: Wouldn't they have to pass?

MR. ARMSON: Yes, it is obligatory.

MR FREIDIN: Q. And would they understand the workings of the nutrient cycle and the relationship between pools and fluxes to the extent that perhaps someone with your qualifications would?

A. No.

MS. SWENARCHUK: Mr. Chairman, excuse me for interrupting this early, but surely this witness is not in a position to describe how other people understand...

THE CHAIRMAN: Speculation, although you may...

MR. FREIDIN: Q. Well, let me put the question this way: It is expected that practising foresters would understand the relationship between pools and fluxes and all of the mechanisms that cause things to change in the same way that someone with your qualifications would?

A. No, I would not expect it.

Q. Why not?

A. I would think that their daily activities are directed to other matters, more direct matters and that the concept of pools and fluxes and certainly those words wouldn't be in their minds at the time when they are viewing an area for -- assessing it for possible harvest and so on.

They would look at -- they would see things there that would relate to it, but I don't think they would think about it in quite those terms.

Q. So could you answer this question then: Do foresters actually measure the cycle, by that I mean actually quantify the rate of decomposition and that sort of thing for specific sites when they are in the field making silvicultural decisions?

A. I am not aware, when I have been out with them, of any of them doing it in that sense, no.

Q. And, again, do you believe that it is reasonable that they do not make those kinds of calculations?

A. Yes.

Q. Can you advise: How would a forester take the scientific principles that you have described into account when they are managing the forest if the forester doesn't actually measure and quantify all of

these relationships?

A. Well, there are three, perhaps four, but certainly three attributes of the forest that I think any field forester, any forester when he goes into a field looks at. It is just an automatic thing.

They look at the trees, obviously. One of the features that they look at is not only the species, but the dimensions and, in particular, the crowns are one of the most obvious things and it is part of the ongoing, I suppose, body of a professional that when you look at the trees and you look at the crowns you are looking at features that may not be that obvious to others.

For example, if I - and I would dare say virtually all foresters - were to look at two stands of trees; same species, same general size but they differed in terms of the density of the crown, the amount of foliage, then that would be something that they would recognize right away, very thin crown, sparse crown. Now, that in a sense is a key to a pool size. So it is an observation that is made that can have a number -- you can make a series of deductions, rightly or wrongly about it.

If it has a small crown if it is a conifer then you, as a forester, suspect there is

something going on here, if you follow me without going in --.

I mentioned earlier the importance of the forest floor. The word the foresters use is duff. I think there isn't a forester I know that I have been out with that doesn't at one stage in the field visitation stick his toe into the ground and kick it. He may not have a shovel, but he looks at the forest floor and he looks at the lesser vegetation, not in terms of the detail of the species, but he looks at it in terms of the nature, the thickness of the floor or the amount of lesser vegetation and, in doing that, he is looking in effect at what we would call pools.

He is also normally looking at the soil itself, what kind of soil is it. But they are usually in terms of texture, just the physical attribute: Is it a sand, is it bouldery, stony, is it a clay or a silt and what are the moisture conditions there; is it wet, dry, so on. These are common ways, they are observations that I would suggest that most foresters going in to the field look at and assess in their own particular way.

And in so doing, they are in effect assessing - they may not think of it this way - they are assessing attributes that I would look at in terms

of pool size, for example, nutrients.

Q. Mr. Armson, could we go through those again and perhaps you could indicate the type of deductions or the actual deductions that a forester would be able to come to as a result of some of these observations.

The first one you mentioned was the density of the crown. You said that was a key to pool size. What sort of deductions could one make based on that observation?

A. Well, it would be the density and that also would be related to colour. If, for example, one were looking at the foliage of spruce and there were, let's say, a less dense crown and also there were -- the foliage tended to be yellowish, then immediately I think any forester would deduce that there was something going on. They may not be able to pinpoint it, but a most probable explanation, a most probable, would be some nutrient would be involved in causing that.

Q. And with that observation and that deduction, could silvicultural decisions be made, reasonable silvicultural decisions be made as to the effect of that or what you might want to or have to do?

A. I think normally the next step would

be to look at a situation in which that particular forest was growing and from the forester's standpoint attempt to come at a most probable reason for it being thin crown and discoloured in a certain way. And that may or may not be something that would necessarily occur to a particular individual, but that's what they would normally look for, the cause for that.

Yes?

MRS. KOVEN: In terms of silvicultural planning though, if you saw a stand that looked like that you probably wouldn't spend a lot of money planting on it?

MR. ARMSTRONG: That's right, or if you were looking -- for example, there was a period which I spent in the field with foresters looking for those various kinds of stands to see how we could in fact improve the growth, improve the foliage by in fact adding nutrients to the situation.

In certain parts of the world in forestry that is a very common thing, you look for stands of that type and you then treat them with the element that is considered to be deficient. We don't do that in Ontario on an operational scale.

MR. MARTEL: I was just going to ask that, if you do it much. My understanding is you don't

do much of it in Ontario.

MR. ARMSTRONG: No. We have had a number of operational trials in various areas, in the area of the undertaking, particularly in the late 1960s and early 1970s, but that is not an operational thing, for the major reason that we do not in fact have significant areas where we have observed these deficiencies in existing stands to any major degree.

This is not to say that stands that exist out there could not be treated with additional levels of nutrients and have increased rates of growth. That's another matter.

Coming back to the original question about the silvicultural implications, if that stand were to be harvested - Ms. Koven's question here - then I would think that the forester in looking at it -- for example, if there were a very limited forest floor, which could be one of the reasons for whatever cause, would then look to either putting a species on it, if he wishes to regenerate it, one which would have a relatively low demand for what he considered to be the deficiency.

And the best example I can give you is that if the stand that were there were spruce which has a relatively higher demand for nutrients than jack

pine, then the silvicultural decision that would flow would be: Well, maybe we should regenerate this with jack pine which can grow relatively well on low level fertility rather than try and reintroduce spruce to this particular area. I think that is the best example I could give you of a silvicultural decision really.

MR. MARTEL: Can I ask another question. Mr. Freidin asked you if the average forester understood all of the things that you outlined for us here today, but in early evidence from Mr. Kennedy, in particular, we talked about the eco-systems and the manuals or the books being prepared for people.

Is that what all that's leading to, you are preparing those types of material so that the forester won't have to know that specific material but can refer back to - without taking all the calculations or attempting to do so; is that what the purpose of that is?

MR. ARMSON: Yes. The purpose of, for example, the eco-system that was referred to by Mr. Kennedy, the classification that is, there were a series of what were called operating groups or types and these had implications in terms of fertility and moisture supply.

And that is correct, yes, the foresters

within that region would then become familiar with those types.

MR. FREIDIN: Q. And would silvicultural guides be something which are available as a tool to be used by foresters which would address Mr. Martel's question?

A. Yes, very much so. The Silvicultural Guide for Spruce does in fact do that.

Q. And following along then from the question from Mr. Martel, is there certain science -- scientific knowledge incorporated within management tools like silvicultural guides and forest eco-system classifications?

A. Yes. Over time there are research studies, scientific reports, various kinds from various areas, but especially those from the general area of the undertaking or this broad forest area and those are ongoing.

They add to our knowledge and these are in fact the kinds of information which become related then to existing experience, become related and in the evolution become incorporated into guidelines such as the one I mentioned.

I would also mention here, Mr. Freidin, that that is one of the reasons why within the

Ministry - and I referred to this in an earlier panel - the technology development units were specifically put in place to form a bridge, if you like, between the results from the scientific community and the scientific community itself and the field and forest managers, whether they be Ministry or industry, and to form that bridge to further both the identification, if you like, of problems and bringing to those problems the appropriate scientific expertise,

And also from the results of scientific endeavors to translate that, if you will, into what seemed to be the appropriate understanding and manner in which those findings could be transformed to application in the field management.

Q. Mr. Armson, during one of the scoping hearings - and I believe it was Panel 9, but I don't think it is that important - the solicitor for the Ministry of the Environment posed a question. He said: Whether the database available to the Ministry of Natural Resources is adequate to allow the principles of nutrient and hydrologic cycle to be applied at the field level when making timber managment decisions; that is, how do you apply nutrient cycling information and information regarding the hydrologic cycle to make decisions?

That was his question, that was his concern and have you addressed that in whole or in part?

A. I believe I have addressed much of that. What we are doing, it is always ongoing. Yes, we are dealing with whatever is available and at the present state I would consider that it is adequate to make the decisions that we have to currently for our timber management.

But we always have to pursue and obtain greater knowledge and there are some areas where those -- that knowledge is less than we would desire.

Q. Now, would it be reasonable or would it be counterproductive to put into a silvicultural guide all of the science, explicitly put in all of the science which leads to the type of direction which is actually contained within them?

A. It would not be reasonable, in my view, it would confuse and confound rather than clarify.

Q. In terms of those silvicultural guides, do you believe that the need to actually refer to the guide for guidance is affected in any way by experience?

A. The guides in themselves cannot

address every situation that occurs in the forest. The management forester in any management unit or situation is the one that has to do that.

The guides, therefore, can provide a synthesis - and this is what we have I believe done quite effectively - of not only the scientific information and put it in terms that are understandable, but they have also synthesized the level of expertise and experience that exists at the time that those guides are put together.

In the guides that the Board will be viewing - and the spruce guide is the one specifically we are referring to here - there were, in fact, a contribution came from field foresters as well as from the scientific area.

Q. And in terms of the need to actually refer to those guides, would you expect that the degree to which one would actually need to refer to those guides vary as between a first-year forester and a forester who had 10, 15 or 20 years' experience?

A. Yes, I would. Both would refer to it, both would refer to it obviously in the light of their own either greater or lesser experience, but certainly a younger forester, I would expect, would refer to it to a much greater degree.

MR. FREIDIN: Mr. Chairman, if the Board and the parties do not have the Spruce Silvicultural Guide with them, this would be a convenient time for a break. I wanted to ask just a couple of questions about that guide.

THE CHAIRMAN: Do you have the exhibit number on that?

MR. FREIDIN: Yes, it is Exhibit 382.

THE CHAIRMAN: 382. Okay. We will break for 20 minutes.

---Recess taken at 10:25 a.m.

---Upon resuming at 10:50 a.m.

THE CHAIRMAN: Thank you. Be seated, please.

MR. FREIDIN: Q. Now, Mr. Armson, just before the break we were talking about the silvicultural guide and documents like that which provide direction to field foresters, and we talked about certain scientific things like the nutrient cycle and the hydrologic cycle being built into or implicit in some of those documents.

Could you, by reference to Exhibit 382 which is the Silvicultural Guide for the Spruce Working Group, show how in fact direction given in a silvicultural guide would be based on the science of

nutrient cycling?

A. Yes. If the Board would take the guide and turn to page 54. On page 54 --

Q. Just take a second here, let me get -- okay.

A. And I would refer the Board to the second last paragraph on that page and that is the paragraph that begins with the words:

"Shallow and very shallow sites..."

Q. Perhaps we should just read through that.

A. And I will read through it.

"Shallow and very shallow sites require careful site preparation to achieve the desired results and to maintain site productivity. Mineral soils or partly decomposed materials must be exposed to provide suitable seedbeds or planting sites but..."

And this is the important part:

"...but removal of the organic layer should be minimized to retain nutrients. on these sites and on deeper soils intermittent hatch, scarifiers and trenchers have proved effective."

So you have in that paragraph the bringing into it of a knowledge about nutrients in a very simple sense and also you are bringing into it some experience. The last sentence refers to the type of equipment that has been found effective.

MRS. KOVEN: Is that unique to spruce working groups, or is that the sort of -- that seems like standard knowledge that you would find in all the silvicultural guides?

MR. ARMSTRONG: That would probably be -- in similar words perhaps would appear in some of the other guides, yes, certainly in terms of jack pine or white pine. That is true, Ms. Koven.

MR. FREIDIN: And we will be making those silvicultural guides available if requested as the new ones come out.

Q. I understand there is another example, perhaps you could direct us to on page 55.

But before you leave that, would there be some sort of chemical or more complex explanation as to why doing those things would have the effects that are suggested?

MR. ARMSON: A. Well, first of all, the admonition here is the removal and that is in fact: Don't take away or remove the pool.

Secondly, it also is talking about, if you like, the disturbance of this which they don't say: This is going to increase the decomposition, but that's in effect what will happen. But the key thing here is removing the pool size which is the organic layer.

Q. And the example on page 55?

A. Yes. On page 55 there is another example and this is related to -- it is under the page -- it is under the 3.3.1.2 titled: Prescribed Burning, and the last paragraph after the bullet points in the middle of the page talks about prescribed burning and you will note that in the last sentence it says:

"Nutrients are mineralized by fire which may enhance growth."

This is a reference to the fact that from both studies and -- scientific studies and observations, the burning of organic material - I think the Board would appreciate - this results in ash and the ash is very high in soluble nutrients, particularly calcium, magnesium and those nutrients, to some degree phosphorus.

Q. And so in that particular case we have direction in the first part of the paragraph with a very short sort of explanation perhaps as to why that

direction is given? Is that what appears there?

A. Yes. It is giving the direction that if you do this then you are going to increase, in effect, the supply of nutrients, certain nutrients to that vegetation.

Q. Thank you.

MR. MARTEL: Can I ask a question? It says:

"Prescribed burning is effective site preparation tool on all sites except for very shallow soils..."

Okay, I had misread that, except for.

MR. ARMSON: Yes.

THE CHAIRMAN: I take it, Mr. Armson, that where there is scientific literature that will support some of these propositions, that would be contained in the references in the guides, so that the forester could go to the actual source document; is that correct?

MR. ARMSON: In not all cases -- no, that is not correct.

THE CHAIRMAN: Okay.

MR. ARMSON: Much of the scientific literature upon which this is based, there is a considerable body in the bibliography, but there may

well be scientific studies which have become incorporated but which are either not readily available or of a nature that a forester who is reading it would have difficulty in accessing it.

These are the more commonly available -- and I think you will see that the majority of the material that is listed here is from Ministry publications, from publications of the Federal Research Agency and of journals that are normally Canadian journals either of Botany, of Forest Research, or the Forest Chronicle which is a publication of the Canadian Institute of Forestry.

So this is the material that a forester could normally access would...

MR. FREIDIN: Those references commence at page 69 of the silvicultural guide.

Q. Thank you, Mr. Armson. Now, we have been speaking primarily about a situation where you are discussing the nutrient cycle in a non-disturbance environment. And, Mr. Armson, what happens if you introduce disturbance - and I am going to limit the question to disturbance through dynamic natural agents of change - into the situation that you have described to this point?

A. Well, if I might, there are three

natural disturbances that the Board has heard discussed and indeed has had descriptions and examples cited in previous panels.

Now, the first one is fire, the second one would be insects, and the third would be wind. And if I might just very briefly elaborate what, in a general sense, the effects of those three major disturbances would be.

Q. That is on the nutrient cycle?

A. This is on the nutrient cycle. Yes, this is strictly on the nutrient cycle. And if I may, I will refer to it in the sense of pools that are lost, changes in flux and the dynamics that go on.

So with the fire the most obvious thing is the removal of one of the major pools; that is, the vegetation itself, it is burnt, it is consumed. And much of the nutrients, a significant part are lost. The nitrogen is lost into the atmosphere, so there is a net loss of nitrogen from that pool.

Much of the other nutrient content of the pool; calcium, magnesium, they are all in the form of organics, is in fact converted to ash readily available, water soluble which either goes off into the atmosphere and is distributed off in many, many -- great distances from the source of the fire, or it is

left on the forest floor, or what is left of the forest floor, because the fire consumes that because it is also a fuel.

So the net result is to reduce almost totally the pool that would exist in the vegetation prior to the fire. There is a net loss -- a major net loss of nitrogen from that pool, there is also a loss of other elements but there is a significant movement of those from that pool to the surface of the soil.

In terms of the forest floor - and there have been quite a number of studies, one of which I conducted some years ago - from natural forest fires that occur with a frequency of once every 50 years, 70 years, something of that order in our area, in the area of the undertaking but also in other areas of boreal forest-type conditions under natural fire, approximately one half of the thickness of the forest floor is consumed. Now, that is an average. There are conditions where more or less may be consumed, but that I think is a very consistent observation.

Therefore, the ash from that material which is consumed of the forest floor is again added, or part may be lost into the atmosphere because of winds. The ash then from the pool of the vegetation -- the ash that remains from whatever has been consumed

from the forest floor then is water soluble and then can be retained in a chemical sense and we say available as - and here I'm sorry, I have to use - an exchangeable ion.

What it means is the element in an ionic form can be retained on a complex - I'm sorry here - but within the soil, what remains of the organic or what may be within the mineral layer; in other words, it is held, but much of it is lost in terms of water -- precipitation may wash it off on the surface or it may move through the soil and not be retained and eventually go to join the groundwater.

So the net result of a natural fire is to reduce those two pools, to convert the elements in it into a different form and, in fact, a very available form, some of which will be readily available.

Now, this means - and I referred to this earlier - that if the fire occurs at a time of year when revegetation can occur, then the new vegetation has the advantage of a relatively large supply of available nutrients. And this is why after a fire, particularly in late spring or early to mid-summer fire, we often have a tremendous lush growth of herbacious and small woody species. In fact, that is the -- and that is why in the silvicultural guide,

after a prescribed burn, it has somewhat the same effect; it can render nutrients more available.

So that is the result from the fire in terms of the two pool sizes. The fire does not directly affect the pool size of nutrients within the soil, the mineral soil itself only insofar as more ash is added and may move through the soil.

Q. If I might, perhaps an obvious question, but you say that the consumed vegetation the trees and the understorey will remain on the site in the form of ash.

A. That's correct.

Q. And are there nutrients in that ash?

A. Yes, the major nutrients are those which we have referred to: calcium, magnesium, phosphorus would be the three major ones and they, of course, have other effects other than just being there in terms of being available for uptake.

Q. And the nutrients that you spoke of interacting with this exchangeable ion--

A. Yes.

Q. --are some of those nutrients the nutrients in the ash?

A. Yes. Calcium and magnesium and potassium, for example, is another one. They are

associated with it.

Q. And when a forest floor decomposes through the process that you described before where it heats up just even naturally, does that same process that you referred to occur?

A. Yes, the normal effect of decomposition of litter, of the forest floor, is by the largely microbial activity, that there is a breakdown of the tissues and a release in two ways, both as a byproduct of the decomposition; that is, nitrogen in the form of ammonia can be produced which is -- we are all familiar with, that is what happens in stables and so on manure piles. You can smell the nitrogen -- the ammonia what is contained in the nitrogen.

And also the microbial population - and this is perhaps not well understood - the microbial population itself increases in size and, therefore, it recombines those nutrients, particularly phosphorus and calcium and nitrogen into its own body system, but the microbial population has a very rapid cycle of return bacteria, fungi and they in turn are broken down.

So you go through stages of decomposition, if you will, in the breakdown of the forest floor, but there is a continual release. It is a much more gradual release - I think this is where the

timeframe or duration becomes important - the provision of nutrients after a fire is a very rapid -- there is a large flux, we would say some of which will be lost, some of which will be retained.

When you have the breakdown of the forest floor, when that is -- that decomposition, there is normally a much slower, more gradual release and it goes in fact through several stages so that the opportunities, if you will, for loss are much less.

Q. And when you say that there is a provision after a fire - the provision after a fire of nutrients - you say there is a large flux. How does the amount of available nutrient differ from after a fire as opposed to prior to the fire?

A. Well, there is a much larger amount of nutrients, not nitrogen, but of the other nutrients available immediately following a fire.

MS. SWENARCHUK: I didn't hear that, I am sorry. Could you repeat that?

MR. ARMSON: Oh, after a fire -- immediately following a fire the ash contains a large amount of nutrients in an available form; not nitrogen, excluding nitrogen.

MRS. KOVEN: Does the airborne ash have an effect on the canopy around the location of the

fire.

MR. ARMSON: Normally - and again I am not an expert in fires and movement - but the airborne material normally, yes, it can have a local effect, but with large fires this often exists over many tens, hundreds, if not thousands of kilometres. When the sky turns red in the daytime after a large forest fire and you can see that 50 or a hundred kilometres away, what you are looking at is suspended materials and that is ash.

MRS. KOVEN: Mm-hmm.

MR. ARMSON: That is then deposited when rainfall elsewhere and this is a very common movement, if you like, for major movements of nutrients. It is quite an interesting phenomenon and can - in fact, many scientists believe that it is responsible for changing the acidity, for example, of lakes at some distance. A fairly similar analogy to so-called acid precipitation, except this is basic precipitation.

MRS. KOVEN: Mm-hmm.

MR. FREIDIN: Q. And Mr. Armson, can you advise: Does the increase in available nutrients after a fire, as you have described, play any role in the revegetation of the site after a fire?

A. Yes, it does. And I referred earlier

referred earlier to the timing and this, I think, is a key feature. If the fire occurs at a period of the growing season where revegetation can take place, then one of the, I suppose you would say, roles of the revegetation is it can trap, if you like -- it can absorb rapidly the nutrients that are there.

If the fire in the same forest were to occur at, let's say in September or even later months but certainly in the fall, then the revegetation in our climate will not occur or be very minimal and, therefore, there is a much greater opportunity for loss over the period of the fall with rains and so on of the nutrients that are there.

And we have had examples in this province of major fires over -- in the history of the province that have been in the fall, though most occur in the spring and early to mid-summer. So that the fire in the same stand at different times of the year can have quite different effects.

Q. Okay. And perhaps you can deal with -- were you going to deal with the other two dynamics; agents of change -- the natural agents of change...

A. Oh yes. I mentioned insects. Normally we wouldn't think of the levels of insects,

insect pests in the forest as being a major factor, but where we have infestations such as spruce budworm in the coniferous forest or insects which -- there is like the tent caterpillar in the Great Lakes/St. Lawrence region which consume, in certain periods, certain years large quantities of the new canopy of a forest.

Then what it is doing is removing that pool from that forest estate and converting it into insect mass which may ultimately appear as moths and so on and, therefore, be dissipated in that sense. But also it converts it to another form which is left in part in the residual -- in the situation, in the form of what the etomologist calls frass which is the droppings really of the larvae.

So you have a removal of the pool in the crown canopy and a conversion into both insect biomass, if you will, and in terms of the droppings on the -- so that is one example. We don't normally, I think, associate that, and I am not myself aware of any particular studies that have attempted to quantify that change. There may be, but I am not aware of them.

The other natural disturbance that, and quite visibly changes the location and nature of the pool size is wind. And although this, in a sense, is perhaps somewhat more limited and the extent often is

less, but there have been major wind disturbances.

Northwestern Ontario particularly is susceptible. There was one I believe last year I think in the June period and certainly over the years there have been a number in northwestern Ontario where very large areas have been windblown or windthrown.

So what happens then is that the pool of forest -- the forest pool of nutrients in the trees is suddenly put in a different location, it is down to the ground or very close to the ground. So you are building a large -- you are enhancing the forest litter but, in this sense, you are also depositing on top of the litter and you have changed then the relationships. And this is -- I have used the term, it is something like we call a green manuring, if you take cuttings off your grass and put it on your garden - we use the term green manuring. Well, this is in effect just putting all the nutrients in vegetative form back down onto the soil where they then will decompose more rapidly because the trees are dead.

Q. Are there any observations that you believe should be made in terms of the flux in relation to those last two natural dynamic agents of change?

A. Well, in terms of the insects there is very little. As I said I am not -- I don't know of

any specific scientific studies. I think that -- it would be my opinion that the changes there, the droppings of the insects would normally be material that is more readily available. So in that sense, the flux would be enhanced, but not in a dramatic sense such as with in terms as it would be in ash from the fire.

In terms of the windthrow situation, the only way that that large mass of material, vegetative form on the ground can be transformed is by decomposition and there it will be a slow, relatively slow process. It will take normally many years for that to decompose totally, but it is a slow process as compared with fire which is a very rapid transformation.

Q. Okay. Now, is the change to the total nutrients on the site, say as a result of fire, a net gain a net loss, or no change?

A. With fire there is always a net loss.

Q. And in terms of site productivity, can you advise whether having that net loss of nutrients is positive or negative, can you generalize?

A. No. It could be positive, it could be negative and it could bring about no change. And if I might explain that.

Where there is, as I suggested to the Board, in the natural forest under fires that occur in that situation, the net loss does not result in lowered productivity. The frequency of the fires -- the fires occur every several decades - 50, 60, 70 years - and under those conditions, there is no evidence that the productivity has in fact been lowered by the -- in terms of the nature of the stand. In fact, if anything, we have evidence that the initial growth is enhanced by virtue of the ash, as I have explained.

Where we note reduced productivity - and we can measure this in terms of growth and we also can identify it with much reduced pools, residual pools of nutrients - is when after one fire we then have a second fire that will occur on the same area within something of the order of 10 or 15 years. This is again documented and I have personally documented this. What happens is that the new pool that has arisen from the first fire, the young stand of jack pine, black spruce, poplar which in fact is growing very vigorously as a result of that first fire, constitutes a fuel mass in the first few years which is very close to the ground, there is another fire.

You get usually extremely hot fires because of this dense fuel mass near the ground and

then not only that is lost but whatever is left of the forest floor from the first fire is often consumed. So that you have, if you will -- you have had a net loss from the first fire, but the system -- the forest floor and the amounts of nutrients that are left, result in a rapid regrowth. Then you hit it again, if you will, with a fire, takes out the residual pool - there is some ash but there is also some more loss - and the loss then and the residual pool size are diminished to the point, in most instances, where the regrowth that occurs is limited by availability of nutrients. And this is a very common occurrence when you have a double fire within the first 10 to 15 years.

After that time, when the fire occurs say 20, but more particularly 30 or 40 years, there has been a litter fall return over that three decades. The canopies have moved up. Yes, you will have a hot fire, but it tends to revert more to the condition of a first fire, if you will, when though there is a net loss you have enough ash and you have enough built-up forest floor.

Those are the conditions under which you would either have no change or a major change in productivity.

Q. All right. And would you agree that

what you have just described could be described as an explanation of the significance of frequency and intensity of a change?

A. Very much so.

Q. And knowledge of that sort of effect or significance is knowledge which can be used in terms of making sort of human decisions about what you want do in the forest?

A. Not only can be, but it is.

MR. FREIDIN: May I have one moment, Mr. Chairman.

Q. Now, you have given an example of how the frequency and intensity of a disturbance can have a different effect. In my opening I have referred to two other concepts, if you will, magnitude and duration. Could you perhaps speak to those two concepts in terms of what differences they might make in terms of effects on the forest estate?

A. Yes. I think in the two examples I gave the Board, one of fire and the other of insects, the magnitude, and if I could refer the Board to Panel 2 when I in the evidence provided illustrations of the growth of the budworm epidemic in terms of insects and the many hundreds of thousands of hectares that were areas of major defoliation. So there is an example of

magnitude.

The other example, the fire - if the Board will recall I had a large photograph of the fire that occurred in Red Lake I believe in 1986, the Red 7 fire - and that was an area of several hundred thousand hectares and, again, that is an order of magnitude of an area of the forest in which the pools, if you like, or the flux changed very dramatically and those obviously can be contrasted with the areas of disturbance by other causes; wind for example, which tends to be more local and is not as large, although it may occur over several hundreds - perhaps a thousand or two, but several - you are dealing with an order of magnitude of hundreds.

The other factor duration. Fires may in fact - and again I am not an expert witness - but fires may be fires that move very rapidly through an area because of climatic differences, wind and so on and, therefore, burn less. The duration of the fire may be such that less of the pool is consumed, even of standing vegetation. In other instances it may be very intense -- not only an intense fire, but burn more slowly.

So those are the ways in which, in terms of both fire and insects, the magnitude, the intensity

would occur.

Q. Okay.

THE CHAIRMAN: Mr. Armson, did I understand you to say that in most of the area of the undertaking most areas -- most stands will be visited by fire about once every 70 years?

MR. ARMSON: The frequency of fire in the natural forest was of the order of 70, a hundred years somewhere. It will vary with the conditions but, yes, that is the origin of our forest.

THE CHAIRMAN: And does that cover the whole forest or will there be stands that are completely exempted from this process?

MR. ARMSON: Oh, there will be stands that will be missed and when I say that, it obviously doesn't cover the area of the undertaking in any few years, it is over a period of 70 to 80 years that this occurs.

In fact, we look at that kind of a frequency in terms of -- when we looked at our age-class distribution of most of our boreal species, as Dr. Osborn showed you, most of that has resulted from fire naturally, but also then, in more recent years, the last 50 years from the protection of certain areas of the forest against fire.

MR. FREIDIN: Q. So the figure you gave of every 70 years or approximately, that is in a situation without fire protection?

A. That's right. That is a natural one.

Q. Okay.

A. I wouldn't suggest it was exactly 70, but it is of an order of magnitude of 70 or a hundred years or something like that.

THE CHAIRMAN: You are referring to totally natural fire?

MR. ARMSON: Natural conditions, that's right. There will be areas and stands the fire will miss for geographic or other reasons, but that is the general sense.

MR. FREIDIN: Q. Now, that general observation as to the frequency of fire in the natural--

A. That's right.

Q. --setting, was that evidence meant to apply to both the boreal and the Great Lakes/St. Lawrence forests?

A. The frequency in the Great Lakes/St. Lawrence would be somewhat longer, there would be a longer time interval, I would suggest, because of the -- and the areas that are burnt would be somewhat

smaller because of the nature of the natural vegetation, the broad-leaf species and so on being less prone.

MR. MARTEL: In your material that was prepared, did I get the correct impression that if you don't have some of this material burnt because of your practices of fire prevention now, that in fact that can be detrimental?

MR. ARMSON: Yes, that is an appropriate inference. In fact it is -- if in our situation -- in our climatic situation, particularly in the boreal but also to a large degree in much of the Great Lakes/St. Lawrence, the rate of decomposition of the forest floor under natural conditions is much less than the rate at which material is being added to it.

So in fact what we find when we look at the older stands that have been missed by fire, where the frequency is 200 years or something greater, in fact what we find is a build-up of the forest floor of poorly decomposed material and this locks into the pool a large amount of unavailable nutrients. So that in fact as we - and it has some other consequences too I may say - that as that goes on, the productivity, if we use that term, of those areas becomes less, unless another major disturbance comes through.

As a result of poor decomposition, the forest floor becomes more acid, there is a host of ancillary activities that then go on to in fact render it less productive.

MR. FREIDIN: One moment, please.

Q. Okay. Mr. Armson, I would like to now move into the area of human disturbance. Can you advise what happens if the disturbance is through human activity? Are the effects different than the ones that you have described as a result of natural disturbance?

A. For the most part the effects differ not in absolute terms but in the degree and by that I mean, that where a fire -- where insects may consume the crowns or the tree forest, harvesting can remove all or part, where a fire can result in increased availability, as was noted in the silvicultural guide a prescribed burn can result in increased availability in mineral nutrients.

Where we do not burn but we in fact harvest and expose the area as it might be exposed by windthrow, or by in fact insects demolishing totally the crowns of trees, the foliage, so that increased temperature, increased moisture at the forest floor level can occur so that decomposition is increased -- the rate of decomposition increases, then there will be

a change in the availability of nutrients related to that decomposition -- those decomposition processes.

So that those are all related. When we site prepare an area by disturbing the forest floor, we are breaking it up. This is commonly results in fact in increasing the rate of decomposition it is a well-known -- that has been known in the forestry world from the 19th Century on. And we know that that then creates, as I say, a greater availability of nutrients.

When we, by some means, remove part of the pool size, sometimes the surface layers which are poorly decomposed, and expose the lower part of the forest floor which is better decomposed then we have not only a better seedbed physically in many ways, but we allow the roots immediately to get to an available nutrient supply.

There are many, many ways in which the disturbances which relate to natural conditions are not mimicked exactly, but we have parallels which differ maybe or may not differ in terms of the processes but certainly may differ in the intensity, the magnitude, the duration over which they occur.

Q. And from that answer could you advise: Is there any relationship between clearcuts and natural disturbance in terms of frequency or

magnitude?

A. Yes. In relation to fire and insects, which I would suggest are the two major ones that we are dealing with, obviously the magnitude of clearcuts in relation to natural fires and major infestations of insects such as the budworm and the tent caterpillar, the magnitude is much less in terms of clearcutting than it is in terms of those infestations.

In the intensity there may well be a removal in terms of clearcutting, an absolute removal of the forest vegetation. There is normally with fire.

The duration. There we referred to the duration, frequency of fire in the natural forest, 70 or a hundred years. That is very close to really the kind -- the types of rotation ages that we are looking at under management. Certainly we are looking at 60 years and upwards for virtually all the area within the undertaking, mostly 70 years and better.

In terms of repetition of fire, however, we are not clearcutting areas in 10-year cycles or 20-year cycles or anything approaching that. So the cycling, the periodicity between the time of clearcutting and the next clearcutting is an interval close to that of the natural fire when you don't have a

second burn.

Q. Just a moment, Mr. Armson. What about the -- can you make any comparisons between natural disturbance and man-made disturbance through timber managment activities in terms of controllability, your ability to control the frequency, the intensity, the magnitude and the duration?

A. Well, the activities under timber management are part -- flow from both a planning process and, if you like, controls of implementation that are quite different from the natural events.

The decision where to harvest, the extent of the harvest, the time of the harvest or any of the other activities, for example prescribed burning. I referred to the differences in effect when you have natural fires occurring at different times in the year. Obviously, with prescribed burning, the time of setting the fire, and the degree to which the intensity of the fire, duration, that is under a high degree of control.

In terms of site preparation, other activities, the control is again there in terms of when, how, and to what intensity the forest floor may be disturbed and, therefore, decomposition or accelerated decomposition brought about.

If I might, there is one other factor

that I would suggest is commonly overlooked and isn't dealt with in any detail in the evidence, but the size of the pool as it relates to the density of the stand is an important factor.

Very simply put, if a natural forest of jack pine has something of the order of 2,000 stems to the hectare at age 60, for example, we would regard that as an extremely dense stand.

If we were putting a new stand in place and, in fact, we may not be looking to that type of density, we would look at a smaller number of individuals -- smaller density.

And I believe we have endeavored - and the Board will hear more about this in a subsequent panel in the tending and thinning of stands so that you in fact reduce it.

So what you are doing, in effect, then is changing both the size of the pool and also the demand for nutrients. This is a factor that is often mitted in many considerations.

Q. Now, in terms of nutrient cycle, Mr. Armson, I understand that there has been in the past concern or questioning about the relationship between human disturbance and continued site productivity?

A. That's correct.

Q. And could you perhaps provide some background, historical if you will, to that particular concern?

A. Yes, I can. I will be very brief in this.

The history within forestry of concern about site productivity essentially - and it was initiated in the mid-1800s in Germany where we often think of forestry sort of in its current sense, developing - and in the mid-1800s, there was -- in fact there was published a German, I believe by the name of Hier published a book on forest growth as it related to what we would think of as site or soil conditions.

And he related it primarily to the nature of the geological materials, where there were soils that were developed from limestone, they were more productive and beech and so on grew there and over here there were coarser soils, gravels and pine and so on.

What then happened was that in the period in Europe, and particularly in Germany and France, but I would suggest Germany was the best example, the intensive use of forest for two purposes -- well, three purposes: One for what we would think of as normal industrial use; that is lumber, timber and industrial fuel, by means -- you in effect cut the trees off just

as we do now.

But on top of that there was a very great and intensive use of the forest for firewood, fuel wood by the rural inhabitants and also - and this may sound - by the rural inhabitants of the litter of the forest floor primarily for bedding use in animals, with animals in the stable. And there was a tremendous amount of litter picked up annually, both in the form of twigs and branches and so on, and the actual needles, particularly the conifers, and that was removed.

And after some time, I would suggest it must have been several decades, it became evident that this was having an effect on the growth of the existing stands, there wasn't something for a new stand. And it also happened to be a period of tremendous burgeoning knowledge about what effects plant growth, and particularly soil fertility. In other words, there was a kind of a coalescence in here.

And, as a result of that, a great deal of attention was paid to the -- and also the methodology for doing chemical analysis really came into play in the late 19th Century.

So these three factors: The knowledge about soil fertility and relationships particularly to

agricultural crops; the tremendous removal of forest floor material, particularly from stands in Germany, managed stands; and the ability to measure nutrients. And as a result of that, there were a number -- many, many studies and a very famous text by a German by the name of Abramier who documented the loss.

This was one of the -- probably the first documentations of someone attempting to measure what was in trees, what was in the forest floor, what -- he had difficulty in assessing the mineral soil, but how much was being removed and where was it going.

It very quickly transpired - and this I don't think needed a great deal of - if you keep removing litter, the annual return from the vegetation, then sooner or later you are draining the pot, you are in effect taking your capital away from your investment.

So there were a series of -- and I can't be too specific, but in the late 19th Century a number of the German states brought in laws prohibiting peasants, rural people from in fact taking out litter and taking out branches from the forest.

So that was the first point at which there was a real concern about what we would say nutrients - they didn't use the word pools - and

cycling within the forest.

Subsequent to that, and particularly in North America, there was very little concern about nutrients because what we were -- as I explained to the Board in Panel 2, we were in a period in the turn of this century, and up until the middle part certainly, in a period of exploiting a natural forest which was in fact rich in pools and the nature of the pools, both trees and understorey vegetation.

What we did have during this period, however, were studies related to the putting in place of forests both in North America and in Europe -- western Europe, United Kingdom, parts of Holland and other countries, but particularly the United Kingdom, of putting in place - and Denmark, I should say, is another country - putting in place forests back on areas that had been, maybe centuries before forested - and, in our case, we didn't have to go back that long - the forest cover had been removed, the area had been transformed from a forest use to an agricultural use either by cultivation or by grazing.

And the example, again, I would refer the Board to is the one I showed in Panel 2 of the pines that were cut in southern Ontario outside the area of the undertaking, particularly on the lighter soils, on

the sands, they were farmed primarily for wheat, they were farmed out, the fertility was lost. Keep in mind that these had been burned areas that were cleared and burned and cultivated.

They then were, because of the nature of the soils, subject to wind and water erosion so that the upper weathered portion of the soil was removed and these were areas, both here in southern Ontario and in parts of the upper lake states, were areas that were then considered barren. There were attempts in the 1920s and 30s to reforest them and, in fact, the reforestation was extremely successful, particularly with species of relatively low nutrient requirements such as red pine. These are the red pine forests, of much of southern Ontario.

In certain areas, not to a large degree in Ontario although we did have some examples, but in upper New York State there were -- some of the growth of the pine was poor, it had thin crowns, it has discoloured foliage. And there is a very classic set of studies that have -- and I mean that in the true sense, that were initiated by a Professor Heiburg from the State College of Forestry at Syracuse on potassium deficiency in the areas of these sandy soils in New York State. And it was potassium, because

interestingly there, they had not only cut the trees and then burned all the residual material, but the ash, instead of being left, had been exported. We are familiar with the term pot ash, but it was one of the first cash products essentially of the early pioneering and early settlement. So the soil was denuded.

The red pine forest came in and there was an interest then. But by and large, in terms of the natural forest, there was very little interest in nutrient availability some, but very little, until with the mechinization of harvesting as it occurred not only here, but elsewhere in North America and also in Scandinavia, with the mechanization and the fact that we had operations that were occurring throughout the season.

It wasn't only a question of harvesting trees in the winter, it was harvesting them in the summer and you get quite different effects in terms of affecting pool size. If you just think about it, when you harvest a tree in the winter time and it is frozen, there are a lot of branches break off at the top and go to the forest floor as compared to the summer if you are taking it out.

So there was the mechanization, the removal and the degree of removal. And so I would

suggest that, particularly beginning in the late 60s, but mainly into the 70s and 80s there had been a plethora of scientific studies dealing with how much is removed from a forest when you extract "x", "y" or "z" amounts of the pool, what happens when you prescribe burn.

There are many, many studies on the effects on the soil of prescribed burning, particularly in the southeastern United States where it is a very common and major form of site preparation. So there has been a tremendous development of scientific studies on nutrients and how nutrients are affected in forest conditions by silvicultural activities, by harvesting particularly since the 1970s.

MR. MARTEL: This almost calls for then, Mr. Armson, a leaving of a certain amount of slash in the forest then when you are harvesting?

MR. ARMSON: Not necessarily, Mr. Martel. One of the, I think, conclusions that comes out is that again it all depends. If the amount that you were removing in the harvest, and given that you were removing -- let's say, you are removing all the tree side, that may be a significant amount, may be many hundreds of tonnes per hectare, let's put it that way, or kilograms per hectare, but if the pool size

that is in the forest floor is large too, and if the pool size in the soil, the mineral soil was large, then in fact what you are removing -- consider that what you are doing is removing an amount over a period of, let's say, 60 to 80 years, that amount may in fact not be large in relation to the total capital that you have, and it certainly may have no effect on the rates of flux that come from that capital.

And that's really -- you have gone to the crux of the question: What is this amount in any given situation. And the problem that we have, the real problem that we have is that endeavoring to determine the flux, the rate at which nutrients are coming out of the mineral soil or from the forest floor - there we have a little better - is very difficult and in fact we have not been able to address it properly.

MR. FREIDIN: And as I indicated in my opening, Mr. Martel, we will be addressing the logging method of full-tree harvesting where slash is not left in the bush. So we intend to deal directly and perhaps in a little bit more detail with the very specific matter that you have raised.

Q. Dealing with that particular matter then, Mr. Armson, you indicated that the activity of harvest using mechanized equipment was a catalyst for

perhaps a renewed or heightened interest in this relationship between biomass removal and site productivity.

A. Mm-hmm.

Q. Panel No. 10, Mr. Oldford in particular, will be dealing with the various logging methods used in Ontario. But I understand the evidence that you are going to be giving about full-tree harvesting, I understand that it is going to be necessary for you to step on Mr. Oldford's toes a little bit and give a brief explanation of the logging methods which are used -- commonly used in -- well, are used in the area of the undertaking?

A. Yes. And, again, I am not a competent authority on logging, but I think generally as a forester I understand the three methods.

There are three. The first one is the so-called shortwood and that is, in effect, a system whereby the trees are harvested, the stems are then cut into some fixed length, four-foot wood, eight-foot wood, sixteen-foot wood so on and the residual -- there is usually a residual amount of stem with too small a diameter and the crowns are then in effect left.

So that in the shortwood system only a portion of the bole is being removed in fixed lengths

and the bole wood, of course, contains relatively little amounts of nutrients. The bark contains some but bark, of course, doesn't constitute a large bulk or mass of what is removed.

Q. The bole wood being...?

A. The bole wood being the stem, the stem.

Q. Okay.

A. So the net result -- and again, Mr. Martel, if one looks at that, without getting into detail, you say in effect you are removing a minimal amount of the pool size from the forest condition under that condition.

The second type of harvesting method is the tree-length where the trees are felled or sheared normally. The crowns up to a certain diameter are then cut off, side branches are stripped from the tree length and the tree length is then removed. So that you are leaving in essence the crowns of the trees and the branches have been -- up to some point have been taken off and then it is sheared and the residual tops are left.

So that that is very similar, really very similar to the shortwood. It may remove somewhat smaller diameter -- up to a smaller diameter of the

stem, but the crowns are in effect left.

The third type, and the one that I believe has caused the greatest amount of concern where there has been a variety of studies, have been that where by the tree are felled and then removed totally. And the crowns are then -- the trees are taken to a central point and the crowns are then removed by some mechanical means or another and left in a pile and the bark may be even taken off at that point.

But what it means is that the crowns, in effect, are removed totally from the area in which the tree was growing and concentrated usually at the edge of that area.

Q. All right. And that latter method is referred to as the full-tree harvest method?

A. That is the full-tree harvesting system.

Q. Okay. Are you able to generalize what the distribution of the nutrients are within the tree; how much in the stem, how much in the leaves, how much in the branches? Is there any generalization you can make?

A. Yes. The majority of nutrients are in the foliage. Obviously then, if one is dealing with a hardwood forest, a deciduous tree such as aspen and

you fell those trees in the leafless condition, then you're, in effect - even though it is called full-tree harvesting - you are not taking out the foliage. So you are leaving, in effect, a large proportion of the nutrients there. If you fell it in the summertime you are taking that out.

So there is a situation where the time of the operation, totally independent of the condition or the forest itself, can be a factor in whether you take out a large amount or relatively little because the branchwood is like stemwood and contains relatively lower proportions.

Q. And I understand a little later in your evidence we will be dealing with that particular distribution in a little bit more detail?

A. Yes, we will.

Q. Okay. Now, you referred to there being studies over the last number of years in relation to the relationship between biomass removal and site productivity. Have there been any studies the results of which, in your view, are applicable to the Ontario situation?

A. Yes, there are several.

Q. And are some of those studies from outside of Ontario?

A. Yes, some have been from outside of Ontario, but they have been with species and forest conditions which are not too dissimilar from Ontario.

Q. So as a general proposition then, could you -- or as a general question: Is it scientifically acceptable to base decisions made in Ontario or in any -- based either wholly or partially on scientific results from studies elsewhere?

A. We would utilize those results. I would myself, and I believe generally, you would not immediately take those results in a quite literal sense and immediately say: These are what we are going to use.

I think one balances it, again - as I mentioned earlier - against the knowledge and experience that you have of our own conditions. And I give you an example.

If a study is undertaken in a black spruce forest in northern Quebec; in other words, same species and conditions that we would probably find very similar here, we would look at that and probably put greater weight on that than if it were black spruce from New Brunswick or some other area.

On the other hand, we would not necessarily just take the findings and immediately

apply them. But I would suggest that that is true of any scientific study or -- I doubt -- in fact, I would think it would be unwise to take the results of any single study and immediately from that go and apply it or make deductions about the application to a given area.

Q. More particularly, within Ontario have there been any sort of specific field experiments to measure and quantify the effects of increased biomass removal on the nutrient status of forest sites?

A. Yes, there have been in the area -- as a matter of fact, east of Thunder Bay in the Nipigon area there have been several studies. I can think of two particular studies there on the removal of forest by certain harvesting methods.

Q. Okay. Let's sort of hone in on full-tree harvest.

A. Yes.

Q. Are there a number of studies or are there any studies on full-tree harvest method and the effect in terms of biomass removal in that way on nutrients?

A. Yes, there are. There are studies by Messrs. Foster and Morrison and Dr. Timmer and his associates, particularly in that area east of Thunder

Bay in the Nipigon area.

Q. All right. And I understand that those papers are referred to, two of the Morrison papers are referred to in Panel No. 9?

A. That is correct.

Q. And there is another Morrison -- Foster and Morrison report in Panel No. 10, Mr. Greenwood's material?

A. That's correct, yes.

Q. The Timmer paper that you referred to is in Panel No. 10?

A. Yes, and we have other papers from adjacent jurisdictions which cover some of the -- provide data on this too.

Q. And are some of those reproduced in Mr. Greenwood's material?

A. Yes. If I might, they are reproduced on page 225 of the evidence panel for Panel 10.

Q. Now, I am speaking about the -- if you can turn to page 220 of Panel 10, Exhibit 416A, we find the discussion about specific papers on page 220 and 221?

A. That's correct.

Q. That's where the names -- are the ones that you just referred to?

A. That's right. There are other studies referred to there too, but...

Q. Okay. Now, can you advise, in terms of this full-tree harvest logging method, are there any generally accepted conclusions regarding its effect on long-term productivity of the site; and, secondly, are there any conclusions that have been made as to whether the full-tree harvest method can be carried out and still maintain acceptable site productivity?

A. Yes. If you look at the literature that is cited, particularly in those pages - and I have read that literature - the general conclusion would be that the full-tree harvesting would not be anticipated to result in reduced site productivity for a future forest.

The second part of the question, if you wouldn't mind repeating it?

Q. I think that was the...

A. That was the first question.

Q. All right. Well, the second part was whether any of those studies addressed the -- I think you have maybe answered the question.

My second question was whether the full-tree harvest method can be carried out and still maintain acceptable site productivity. I think maybe

you have answered that.

A. Yes, I am sorry.

Q. In terms of the papers that you have referred to, are the results definitive or are they tentative? How would you describe the conclusions which you find in those reports, if in fact you can generalize?

A. They are tentative because a number of the authors very specifically addressed this matter of the difficulty in quantifying the rates at which nutrients can move from whatever residual pools there are and become available to a subsequent forest.

This is -- and that is both from the weathering of the mineral soil itself and also the decomposition of the organic area. That is very hazily known, I would put it in those terms.

The quantification of the amount of nutrients in the soil by the conventional methods of analysis also poses another difficulty in that the methods of analysis that are used, for example to determine an available level, are arbitrary; they are methods that are conventional, they are used in agricultural soils work, they are used in forest soils work, but I think that any forest soils scientist would say they are, in effect, arbitrary and don't

necessarily reflect the level of soil -- of nutrients available to a particular type of vegetation.

I think those -- in that sense, therefore, any conclusions must inevitably be tentative.

Q. In terms of these scientific papers, do the authors indicate whether, in their view, there should be any prohibition, in whole or in part, of the full-tree logging method?

A. One author, as I recollect one paper, I believe it was Dr. Timmer made that recommendation.

Q. Okay. And we will deal with that in a moment.

In a general sense, do the authors of those papers that you have referred to come to any conclusion or provide any view, their view, as to the application of the results of their particular studies to other geographical areas within -- well, other sites within the same type of forest region?

A. Well, I think that the nature -- the authors very generally make it clear that the results pertain only to the situation that they investigated.

I think that by the very nature of their scientific investigation, they recognize the hazards of attempting or taking results from one specific location

and applying them exactly to another one.

They are looking from their studies to find -- obtain knowledge. In that particular study they are carrying out, they obviously are looking to see if there are, if you like, processes and levels that result from that that they can perhaps make some generalizations. But I think all of them would put a caveat on the direct application.

Q. Are there scientific reasons why this limitation would be put on the applicability of the results to other areas, areas other than where the actual experiment or study took place?

A. I don't know whether I would put it as scientific reasons, but I would say that scientists by nature are very aware of the hazards of taking results and applying them outside of the context of the study. They are conservative in that sense by nature.

Q. All right. Outside the context of the study, if you were looking at a different geographical area, you were looking at a different site, would that take it out of the context of the study?

A. Oh, very definitely.

Q. And the site examined -- taking it out of that particular site, would that be taking it

outside of that particular study?

A. Yes, that would take it out and, as I mentioned, they are very much aware of the arbitrariness of the methodologies in many instances which they are using to measure the amounts of nutrients.

THE CHAIRMAN: Mr. Armson, if you accept that, how could you ever harvest in that method on any site unless you first did a specific study on that site. And even then, given the arbitrariness of the methodology, could you ever be sure even in that case?

MR. ARMSON: I would suggest, sir, that from the knowledge that we do have, the observations that we have of what has resulted from applying something; in other words, our observations, knowledge, expertise and I would suggest, to some degree, are rationalizations. The application of some common sense to it often leads us in a certain direction to say: Yes, we will or no, we won't.

I don't think -- I think that in most areas of endeavor we are always dealing with areas of ignorance and areas of knowledge and we move on the best available knowledge and understanding.

THE CHAIRMAN: But in terms of rationale, you are really involved in almost all cases with a

transposing of information from one place to another?

MR. ARMSTRONG: That's right. But the degree to which you try and transpose it exactly, or whether you take the essence, whatever that may be, and put it in your own context.

The best example I could give you would be a study on full-tree harvesting - this is an example, a hypothetical one - where in fact the amount that is removed in relation to the amounts that are left and the conclusion is that the amount that is removed is far in excess of anything in any of the residual pools and it is the same species.

And if I or a forester looks at it and says: Well, wait a minute though, the pool size in the forest floor there is about one tenth, in terms of just the physical dimension of the forest I am dealing with, I say: Well, wait a minute, I have another -- I have a buffering situation in here in the sense that I have a pool size that was quite different from one of the pool sizes they had.

That is the sort of thing I would suggest you apply it to.

MR. FREIDIN: And I think some of my examination will address the topic that you have raised, Mr. Chairman.

Q. So if I understand your answer to my question about, sir, departures from that particular study, you would agree then that the variability of species would affect the applicability of the results from one study to another?

A. The conditions, the site conditions and that was inherent in the example.

Q. Right.

A. And a recognition that we -- in any of those studies, there is no exactitude in terms of all the elements and I mean that almost literally, the nutrient elements of really dimensioning their amounts and their forms in the system.

Q. And I think you indicated earlier that the state of knowledge in terms of the flux--

A. Yes.

Q. --or the rate at which nutrients become available from reserves of nutrients.

A. Yes. Again, if I can come back to my analogy of the investment. If you are looking at a natural condition with certain pool sizes and you measure the amount that you remove in this case by full-tree harvesting and you are then putting in place a new stand, let's say of the same species - given that - the density of that species - how many you are

transposing of information from one place to another?

MR. ARMSTRONG: That's right. But the degree to which you try and transpose it exactly, or whether you take the essence, whatever that may be, and put it in your own context.

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MR. FREIDIN: And I think some of my examination will address the topic that you have raised, Mr. Chairman.

Q. Okay. Mr. Armson, I would like to just deal, not at too great a length, with those three factors that you have identified; species, the actual sites where the study took place, and this matter of measurement of nutrient cycles.

Could you explain why the variability of species causes the conclusions of those authors to be tentative?

A. Because the demands, the actual amounts of nutrients in a species will vary. And if I might, with the Board's permission, return to the one overhead that I used earlier showing the differences in nutrient levels, concentration in different species.

Q. Yes. That is at page 224 of Exhibit 416A.

A. These were five nutrient elements, the calcium, magnesium, potassium, phosphorus and nitrogen and I was generally referring to differences in levels and this was measured as concentrations - it is a very gross measure - but, nevertheless, does indicate that certain species and I have indicated balsam fir.

You notice that the red pine which is in here, and the red pine is actually the red bar which is pretty well in the middle of each one of those five

sets of histograms; that is, this one, this one -- you notice that the red bar tends to be, in fact I think in every case, is the smallest and I relate that back to the fact that we have been very successful in putting red pine -- re-establishing or establishing red pine on those sandy areas that were very infertile in southern Ontario.

Now, if we had tried -- in fact, where we have attempted in a few locations in the early years to put in other species such as white spruce, many of those stands when they survived - and they often did survive - grew very poorly and were thin crowned and had yellowish foliage.

Q. And just leaving that up for a moment, Mr. Armson, you have indicated that knowledge of nutrient demand in the case of red pine has led to its introduction, or introduction back perhaps to those blow sand areas of southern Ontario.

Could you advise whether this knowledge about the different nutrient demands in relation to particular species has any significance in terms, or could have any significance in terms of making a silvicultural decision?

A. Yes, very much so. For example, in the boreal forest jack pine is much less demanding in

terms of nutrients than white spruce. Black spruce from our -- those studies and observations is generally not a demanding species, more demanding than jack pine but nearly as demanding as white spruce.

Poplar, aspen poplar in particular, is considered to be relatively high demanding in terms of nutrients. So those -- we can rate the species that we commonly deal with in the boreal forest very readily.

In the Great Lakes/St. Lawrence forest sugar maple, hard maple is well known to have a relatively high demand for nutrients as compared with white pine.

Q. Now, we will hear later in the evidence about certain situations which arise where certain sites are converted. By that I mean the species that are harvested are not the species which you attempt to get back. You are familiar with that being referred to as conversion of a site?

A. Yes, I am.

Q. And does that practice occur or has it occured in the past on stands which prior to harvest were primarily or heavily constituted with balsam fir?

A. Yes, that is correct.

Q. And looking at that overhead--

A. Yes?

Q. --does it tell us anything about the kind of site that you would have if in fact you had balsam fir?

A. If you had balsam fir. Maybe I should put the overhead back on.

Balsam fir in this overhead is the second histogram from the left and in this particular one is coloured blue and it indicates that its demand is relatively high, in fact it is the highest of the species that are indicated there. So that if we find balsam fir we normally are looking at a situation, from a forester's standpoint not from that of a scientist, generally a species which has a high nutrient demand -- relatively high nutrient demand.

Q. So in terms of making a silvicultural decision, just knowing that balsam fir was the type of stand that you were going to be harvesting would provide certain cues to a forester -- certain information to that forester as to what he might be able to do on that site?

A. That's right. It indicates right off the bat that you are dealing with a relatively high nutrient supply, a more fertile site than perhaps others which would support another species.

Q. I see.

A. I would just point out again another caveat that in a natural forest the species that occur there don't always necessarily reflect the most suitable species in terms of fertility, but by and large this would be the pattern.

Q. Thank you. Now, can we move on to the second factor and that was variability in terms of site characteristics.

Could you explain how that causes the conclusions of the various authors to be tentative in terms of the application of their studies to other situations, situations other than the situations of their study?

A. Yes. In general course textured soils, sands for example, especially the medium and courser-sized sands tend to be soils which are less fertile than soils which are finer textured. So that if we are dealing with silts and loams and clays, soils of that texture, the finer texture we know that in general the levels of fertility that they can sustain will be higher.

The relationship is not always a simple direct one and I will give you the reason for that. Part of the reason why courser textured soils are less fertile is also because, in most instances, they have a

lower ability to supply water. Now, we are coming into an interaction.

If - and this is the way I would explain it - if water is the limiting factor for vegetative growth, then that in itself will reduce the size of the vegetation and, therefore, the amount and rate of litter deposition. So that on the courser textured soils where water is limiting, you will also tend to have smaller pools of forest floor and because they are drier they will also decompose at a lower rate. So that you have changed automatically the pool size in relation to one factor, moisture, which is in turn related to texture.

But the second factor that relates to this is that the mechanism, the chemical mechanism within a sand as distinct from a clay soil particularly or soils with some clay component for holding or absorbing exchangeable nutrients, nutrients that can then be absorbed, is very low in the case of sandy soils and increasingly higher as the amount of clay in the soil increases.

So it is not only the actual, if you like, physical amount but the degree to which the soil can affect that moisture and also the mechanism for providing a reserve, if you will, of available

nutrients.

THE CHAIRMAN: But doesn't that seem to go against the idea of a clay-type soil having a lower permeability than say a sandy soil and, therefore, less movement within the soil of a liquid medium which you would think would allow for a lower rate of exchange than in a clay soil?

MR. ARMSON: But -- I am not really speaking to the permeability, per se. I understand your question.

The clay soil - and actually I will later on in the evidence be providing an example, visual example - the upper part of that clay which is soil where the roots are is normally fractured because of the roots and so it is in fact more permeable than the clay, the massive clay that is underneath.

I think you are really speaking more of the geological clay than the soil clay, if I may. I am also referring to soils which we call loams which are quite permeable, but which do have an appreciable clay component within them.

THE CHAIRMAN: Okay. So we really get back to whether or not a liquid medium can move quickly through it and just because it contains clay, if it is fractured it can move quite readily?

MR. ARMSON: It can, yes, in terms of the plant and the vegetation.

THE CHAIRMAN: All right, okay. Thanks.

MS. SWENARCHUK: (inaudible)

THE CHAIRMAN: Sat on too many landfill cases.

Do you want longer to confer, Mr. Freidin, like about an hour and a half?

MR. FREIDIN: Sure.

THE CHAIRMAN: We will break until two.

---Luncheon recess taken at 12:25 p.m.

---Upon resuming at 2:00 p.m.

THE CHAIRMAN: Thank you. Be seated, please.

MR. FREIDIN: Q. Mr. Armson, I think we left off and you were talking about the variability in site characteristics on these various studies.

Can you demonstrate the variability or the role variability will play in terms of these studies?

A. Well, yes, the variability in terms of the nature of the soil conditions which we have already discussed, in terms of the nature of the other site conditions, moisture supply, these are factors that will affect the translation of results from one

situation to another.

Q. And I understand if we look at various sites you would have different types of nutrients in terms of amounts, you know, above the ground in the trees themselves?

A. That's correct.

Q. And would you also have variability in terms of the amount of nutrients in the soil?

A. That is correct.

Q. And is that demonstrated in any part of the material which is filed?

A. Yes, that is demonstrated in Panel 10 on page 225, Table 2 and I have an overhead of that table and, unfortunately because the table is a small one, it may be fine print, so I think it would be best that you follow it in the printed book, but I will put the overhead on.

Q. And perhaps, Mr. Armson, would it be possible for you to tell us where we are going before we start looking at all these numbers?

A. Yes. This is a summarization in tabular form of data from a series of studies dealing with one species. In this case we are dealing only with a forest that is essentially black spruce, maybe some variation, but essentially that.

It was summarized by one set of authors as indicated in the title Messrs. Foster and Morrison in 1987 and what it is is a summary giving the age of the stand which ranges from an age of 65 years, the eldest one to 126. That is the first column.

The second column labeled basal area and measured in square metres per hectare is, in effect, the way a forester would measure the density - the stocking I should say, not the density - the stocking of a stand. This is - and if I may, going back to the discussion that Dr. Osborn had in Panel 3 - when we, on a per unit area basis, take the surface areas of the stems at an arbitrary level, in this case a diameter at this height, so-called breast height, then when we aggregate that up, whether they are small trees or large trees - a few large trees will give the same area as a number of smaller ones - we use that as a measure of stocking or occupation. So what we are looking at here in terms of square metres per hectare from a low of, I think, it is 25 -- 23, sorry, square metres per hectare, that would indicate that the stocking of the stand is much "lower in stocking" than one, for example, that is -- I think the highest stocking is 49.

So if you just look at the stands, it would be much more open, much thinner. That would be

the things you would observe. So there is a difference in the age and there is a difference in the stocking.

The third column and it uses some symbols and I will explain those, labeled site but, in effect, is a shorthand description of the texture of the soil and, in some instances, the nature of the material.

For example, on the first one, the title is SL. That means sandy loam and you will see a number of those. There is an SiL which is a silty loam, and in the table the word loess is in there to indicate the silt loam is a windblown material, whereas in the bottom three -- attached to the bottom three symbols of L and SL the word till is there, meaning it is a material that has been laid down by the ice either in advancing or in retreating but it is, therefore, a material which will contain some stones and boulders and indeed are heterogenous. So that is the indication of site.

The next three columns deal with or titled phytomass. Some people might refer to it as biomass. It merely means the weight, the dry matter weight of the vegetation as measured by the aboveground material and the crown -- they have separated out the amount in the crown and the amount in the foliage.

And I would merely draw your attention

there to the orders of magnitude that in the aboveground - and these could be totals - they vary from a low of 50 kilograms per hectare to something like 325 and in terms of the foliage, they -- that constitutes a relatively small amount of the mass.

And then they give the partitioning of the amounts of nutrients; N standing for nitrogen, P for phosphorus, K for potassium, Ca for calcium, and Mg for magnesium and it lists the amounts in kilograms per hectare of those materials.

I am sorry, in the biomass that would be thousands of hectares. The figures are rather small here, but the orders of magnitude are relative. The reference is the document -- the studies on black spruce which have provided this information are listed on the right-hand -- in the right-hand column.

Now, I would draw your attention to the last three lines in this table; that is, the ones beginning at the bottom with 126 years of age, across 49 square metres basal area, so on, that one. The one immediately above it, and the reference there is Timmer et al and that is one of the studies which was conducted in the area east of Thunder Bay in the Nipigon area.

The one immediately above it which has

the age of 110 years of age, 23 square metres per hectare and is labeled at the far right as present study is the study done by Messrs. Foster and Morrison in the same general area, not exactly the same spot.

So those three are the ones -- one of the Gordon's -- or I should say the one of Gordon's, the lower most one of Gordon's on the right-hand side in which it says the site is a peat was also done in that area. So there are a number of studies that can be located.

Now, basically I would draw your attention to the fact that the ages for these vary. The study with the last two sets of data were in stands of the same age and the one above it is 16 years differential, so it is not too much difference in age. But if you will look across, you will notice that even in the studies done in the same area there is quite a difference in the basal area, in the stocking on the stand: 23, 32 and 49; that the site conditions as described by the materials are similar, although one is called a loamy till and the other are sandy loam tills, but the aboveground biomasses - or phytomasses as they are labeled here - are of somewhat similar magnitude in two cases, a 142 compared to 134, and in the bottom one 325, a considerable difference.

And that is then reflected in some differences across here in terms of crown, amounts: 36, 23 and 39 I believe it is, and in the amounts of foliage and the amounts of nutrients; the point being here that from studies done essentially in a similar period and stands that are similar you can get quite different orders of magnitude.

Q. All right. And then there is also variability in terms of nutrients, I believe, in soil?

A. Yes, that's correct. That is not shown in this particular set of data. It is shown in Table 3 which is immediately below that on the same page, and this is from one study - I guess that is not visible at the back. I'll put it up there. I think it is probably easier to locate it in the book.

What was done here was to look at the amounts of materials in the forest floor and mineral soil. This is the study by Timmer et al in 1982 and it relates to the amounts that were within what was considered the effective rooting depth; in other words, pretty well where they saw roots of black spruce. That is the first set of numbers for nitrogen on the left-hand side, nitrogen, phosphorus, potassium, calcium and magnesium.

And then the second set of numbers for

the same elements is for what was considered exploitable depth, in other words, the depths to which we assumed they might reach and this is in metric tonnes per hectare.

The columns on the right under the word black spruce, one is deep and the other is shallow, and these relate to the two sites that were in the Table 2; one of which was considered a deep soil, that was the first one, and the other -- second one the shallow one and what this illustrates is the variability in the forest floor and mineral soil for those elements in those two soils.

Q. And the significance of that variability, Mr. Armson?

A. The significance is that these are measured in an arbitrary way, as I explained to the Board, and just whether a difference, for example in terms of say calcium of 178 tonnes per hectare and 2,324, which seems like a tremendous order of magnitude difference, how significant that is in terms of the supplying ability, it remains still somewhat of a question. Some of them are similar, some of are dissimilar.

Q. Okay, thank you.

THE CHAIRMAN: Mr. Armson, bearing in

mind this kind of variability that you get, is it worthwhile, in your opinion, continuing on with these kinds of studies? It seems that as soon as you conduct a study in a particular area you are going to find the variability in the soils.

MR. ARMSTRONG: That's correct.

THE CHAIRMAN: And the presence of the elements in the soils. It would seem to be more productive to worry about how the various elements affect the growth side of it than worrying about what you are going to get in the soils themselves.

MR. ARMSTRONG: I would totally agree, Mr. Chairman, and that has been the thrust of most of my studies during my scientific career.

THE CHAIRMAN: Thank you.

MR. FREIDIN: Q. Now, Mr. Armson, notwithstanding the authors of the papers that you have referred to have been tentative in estimating the amount of nutrient removal due to full-tree harvesting, did those authors make recommendations or reach any conclusions regarding the advisability of continuing the practice of full-tree harvesting?

MR. ARMSON: A. Yes. One made a very definite recommendation concerning full-tree harvesting, the others did not make any firm

recommendations.

Q. And when you say the other five did not make any firm recommendations, does that mean they didn't make any recommendation either way?

A. No, the other studies came to the conclusion with their recognition of the fact that in measuring -- attempting to measure the amounts of nutrients in the soil, they were using arbitrary methods, that the method of sampling, the variability in the -- not only between sites but even within sites that was so large that in looking at that, for the most part, they concluded that indeed the area which required study, a number of them, was on the fluxes and the changes in nutrients that occurred and which would then be -- presumably could be followed through as its effect on subsequent regrowth.

These studies did not, in effect, look at productivity as measured by the effects on subsequent regrowth. They were only measuring what came off an particular area or what existed there.

Q. Going back to my question.

A. Yes.

Q. Did those five authors -- the studies other than the one, did they make any statement as to whether or not the practice of full-tree harvesting was

one which should be limited?

A. They concluded that it should not be -- that full-tree harvesting was something that should not be precluded on these areas.

Q. Now, could you advise me which paper constituted the minority of one and recommended against full-tree harvesting?

A. Yes, it was the paper that -- in the Table 2 which was in the last two lines and that was the paper by Timmer, et al in 1982.

MR. FREIDIN: Now, Mr. Chairman, we do not intend to get into that paper in any depth, but I believe that this issue, having been raised in the scoping, that I would like to have Mr. Armson address that particular paper.

THE CHAIRMAN: Very well.

MR. FREIDIN: Q. Mr. Armson, if I could, just before I get into that paper, based on the evidence which is available to date regarding the relationship between full-tree harvesting methods and long-term site productivity, does the Ministry feel that any prohibition or limitation on the use of full-tree harvesting would be warranted?

A. No.

Q. Why?

A. Because the evidence to date and the observations that we make do not suggest that full-tree harvesting would be detrimental to subsequent forest growth.

Q. If I could refer you to the one paper by Timmer, and I think you will find that at page 451 of Exhibit 416A.

A. Yes, I have that.

Q. Do you have that?

A. Yes, I do.

Q. And this particular paper recommended that there be no full-tree harvesting on specific types of sites; is that correct?

A. That is correct, that is on page 465.

Q. All right. And could you direct us to the portion on page 465 which sets out that conclusion or recommendation?

A. Yes. Approximately one third way down the page there are a series of bullet points and it says:

"It is recommended that..."

And the first bullet point reads:

"...conventional logging methods exclusively be utilized on fragile, shallow till sites."

Secondly, the second bullet immediately below that on the same page:

"Full-tree and complete-tree chipping operations be restricted to stands supported by relatively deep mineral soils."

And then at the bottom bullet, I think it has some bearing on this, and that is where it says:

"Recommended that intensive short rotation forest management be restricted to the deeper more productive sites in the lake Nipigon/Beardmore area."

Q. Before I ask you a few questions about those three bullet points, arising from the last bullet with the reference to the Lake Nipigon/Beardmore area, I understand that the recommendation made in this particular report is limited to that specific area?

A. That is correct.

Q. And do we find that limitation or qualification of the report in the first full paragraph above the recommendations?

A. We do find only a statement that the study was conducted in the area. The recommendations are generalized and applicable to the site and forestry conditions in the region. There is -- it is extended

to the region rather than to exactly that site area.

Q. Are you aware of what is meant by this region?

A. I can only infer that it is meant to be that either forest region or administrative region, but I take it to be the area generally east of Lake Nipigon and north -- south from -- or north from Lake Superior to possibly essentially the edge of the Clay Belt.

Q. Okay.

A. It is not clearly defined. If I might, Mr. Chairman, on page 453 there is a map showing Lake Nipigon, Lake Superior and the location of the area. There is no scale there, but I am assuming that the region applies to a larger area than just that shown on the map, but I may be wrong.

Q. Now, as I understand the Ministry's view, you do not feel that implementing those recommendations is warranted at the present time?

A. That is correct.

Q. Let's assume that the Nipigon area, as referred to by the authors, is something smaller than the area that you have described you believe it applies to or was meant to apply to, would that change your opinion in any way?

A. No.

THE CHAIRMAN: You are just talking about the recommendation about the prohibition or reduction in full-tree harvesting; are you?

MR. ARMSTRONG: That's correct.

THE CHAIRMAN: Or all recommendations in the report?

MR. ARMSTRONG: Yes, I am not talking about the other recommendations because they don't in fact relate to that particular item.

I would point out, if I may, Mr. Chairman, that the study that is referred to in Table 2 which is called the present study, that was also carried out in the same area and that is in the Nipigon/Beardmore area.

MR. FREIDIN: Q. Let me just ask you a question that somebody else might perhaps be interested in. Why not adopt the recommendation about full-tree harvesting on the limited area suggested in this paper?

MR. ARMSON: A. Because we have in the same area a study done almost within the same timeframe and in the same type of forest that does not make those recommendations and, in fact, comes to conclusions that are different.

Q. And is that paper part of the

material that has been filed?

A. That is correct. That is the Foster and Morrison study of 1987 which is part of the data which is part of Table 2.

Q. I think it is part of the materials filed in your witness statement Panel 9?

A. That is correct.

THE CHAIRMAN: Has there ever been any subsequent literature comparing the two studies or commenting on the discrepancies between the two studies?

MR. ARMSTRONG: I am not aware of it, Mr. Chairman.

MR. FREIDIN: Q. The figures on page 224 of Exhibit 416A, the tables we are looking at, do those - I think you may have referred to this, but I just wanted to make sure that I am clear or we are all clear - does Table No. 2 on page 225 have information in it which deals with the Timmer paper that was at page 451 and the Foster and Morrison study that you referred to?

A. Yes. And I am sorry, Mr. Chairman, Foster & Morrison did -- they put this table together so they did in fact review, if you like, consider that other data with it. I apologize for that.

Q. And we find the Foster and Morrison numbers, if you will, in the third last line--

A. That is correct.

Q. --of Table 2. And the Timmer paper, there were two different sites and we have those referred to in the last two lines?

A. That is correct.

Q. Does the Table No. 3 on page 225 refer in any way to either of those two reports?

A. Yes. The Table 3 refers to the work by Timmer, et al of 1982. And the two sites represented, the one as 'deep' and the other as 'shallow', are the two sites indicated in the table.

Q. The two sites which are the last two references in Table No. 2?

A. The last two references, that's correct.

Q. In Table No. 2 which is above?

A. That's right.. That's correct.

Q. Okay. Are there any reasons other than the existence of the Foster and Morrison report which comes to different conclusions in similar areas for, I guess, not following the recommendation made in the Timmer paper regarding full-tree harvesting?

A. Well, there are a number of reasons.

The Timmer paper assumes what they refer to as a steady state; in other words, that the pools, if you like, with one of course removed, are in some form of steady state. And this is where I believe most other authors and persons and scientists who have studied it make the point that that is the one thing that you cannot assume.

The second point is that the stocking of the stands that are being compared are quite dissimilar, as you will note in that paper. There is a considerable difference because of the nature of the origin of the stands. And if I might refer to the table in the paper itself which is on page 454, you will notice -- that is listed as Table 1 in the document, statement of evidence for Panel 10.

If you go to the right-hand column, you will notice that -- two columns, the first one is the basal area which is the stocking, the aggregateed area per hectare and there the numbers 49 and 32 appear and you will notice -- and here you can see which one is the shallow site and which one is the deep site as indicated on the left-hand side.

But you will notice they also give the stand density here in terms of numbers of trees per hectare and you will notice that 19 -- on the deep site

there were 1,960 trees and on the shallow site 2,140 trees.

And I would just point out to the Board that those are exceptionally -- these are natural stands and these are exceptionally high numbers for the black spruce. And the Board may recollect from Panel 4, I believe it was, when the information on the Survey of Artificially Regenerated Sites was presented, these could be extremely high numbers for black spruce in a black spruce stand.

So that making an assumption that a stand of this density, these numbers, and then taking the data with a steady state assumption and then saying that a new forest, which is obviously one over which we have in our timber management some control and we know the orders of magnitude of density that we will achieve in terms of the harvested spruce, these are at age 126, exceptionally high numbers for that kind of a stand.

If I may, we are looking at translating information to a different size population given what we know about our own management of black spruce and the numbers of stands that we can produce.

THE CHAIRMAN: Well, just trying to simplify it down to some very basics: If you had a very high density, large number of stems or trees, you

clearcut the whole bunch and then wanted to reforest that area, obviously because it had a high number in the first place the soils would be fairly high in nutrients; would they, to support a high number?

MR. ARMSON: No, it may not be a fertile soil. A low fertility can still support a high number of individuals but they will be small.

THE CHAIRMAN: Okay. But then you would look at your basal areas as well; wouldn't you?

MR. ARMSON: Yes, you would look at that too.

THE CHAIRMAN: Okay. I guess where I am coming to is: If you went to replant, restock at a density that would be less than what came out of there--

MR. ARMSON: Yes.

THE CHAIRMAN: --then chances are, if it supported a much higher density with a basal area say that was similar, then it would probably have enough nutrients to support a lesser number; would that be correct?

MR. ARMSON: That's correct. And, therefore, in taking the conclusions here and saying there is a possibility that -- or you should not use full-tree logging because you are going to "deplete",

this is in effect the essence.

If you were going to grow a smaller number of black spruce - and we have already have some doubts about the steady state assumption - then we say: Well, the weight of logic is leaning towards, yes, go ahead and use that conventional, or that full-tree logging system on that if you have to.

THE CHAIRMAN: Okay.

MR. FREIDIN: Q. Going back to the first I think of three factors you were going to mention. The first one was you can't assume a steady state and that the Timmer article does. What do you mean by steady state and why does the fact that they assumed a steady state influence your view?

A. Because, as I believe I indicated to the Board earlier, the supply of nutrients from the residual pools which are still considerable, very considerable, is an unknown.

The manner in which the steady state was assessed; that is, the sampling, it was of a kind -- in a manner that in fact we know there are very large variances and this is why the steady state assumption is -- also the fact that other scientiests, and I believe generally, would not make that assumption except as an artificial one.

Q. And I think you indicated that there were three factors: There is the steady state assumption, there is the difference in the two stands in terms of their density...

A. Yes. And did I say three?

Q. I am advised by Mr. Greenwood that he thought you said three.

A. I believe I did.

Q. Well...

A. Oh yes, I am sorry. In the paper, if the paper is read, the two soils; the deep soil, Table 1, and the shallow soil. There is a description of the activities that took place and the time of year in which the study -- when the material was obtained and it is quite -- in fact, it is very specific that the deep soil was harvested during the wintertime operation and the shallow soil was harvested in the summer. This is specifically stated in the paper.

The amounts -- and this showed in the Table 3, when a full-tree operation takes place in the wintertime, there is a considerable amount of crown breakage because the top of the crown is frozen, and there is a considerable amount of residue therefore left on the soil surface, in effect, as litter.

That when a full-tree operation takes

place, as the one on the shallow soil took place in the summertime when the trees are live, then there is much less breakage and much less residual material.

And what this brings into play is, again, coming back to the matter of timing. If full-tree operations were to proceed on a shallow soil and there were any concern, then I think specifiying that they were to take place in the wintertime would ensure a greater amount of litter being added to the soil then if it were a summer operation.

And I just point that out as a factor that can mitigate to some considerable degree, and that I believe is a feature that...

THE CHAIRMAN: Would you recommend that for any of these areas that have been studied?

MR. ARMSON: I believe, as a forester, if I were in charge of an area with soils that I flagged as being perhaps sensitive in that way, I would say that with full-tree harvesting, yes, I personally would say it should be done in the wintertime.

On the deeper soils, more fertile soils, I don't believe that that is necessarily a condition.

MR. FREIDIN: Q. And in terms of -- you say sites that the forester might identify as being susceptible or being fragile. Are you saying that that

automatically means that every kind of site that is referred to in this paper by Timmer, or is that going to depend on, you know?

MR. ARMSON: A. Yes. Without having personally inspected it, I would say it was one that I might look at very carefully. I wouldn't call it fragile necessarily, but it was one where I would have perhaps some concern as compared to others where I may have no concern at all.

For example, a mixed wood uptill with lots of balsam fir, as I indicated, very fertile, I probably would have no concern about whether it was harvested in the winter or the summer, in terms of nutrient removal.

Q. And just so I understand, on those sites where they had the winter harvest in the deep soils--

A. Yes.

Q. --that's where you had more breakage?

A. That's correct.

Q. And you had less breakage in the summer on the site which was harvested -- in the shallow site which was harvested in the summer?

A. That's correct. So the comparison in the studies -- there is some inequalities there.

Q. Did the authors go back and measure the amount of biomass left on the site, the one in the winter and the one in the summer?

A. Yes. As I indicated, that was on Table 3 of the report and it was on the overhead. Do you wish me to...

Q. No, I don't think that that's necessary, but they would show that result -- looking at it that way, there would be a potential for a larger difference in terms of pre-harvest and post-harvest on the shallow site?

A. That's correct.

Q. All right. Mr. Armson, I would like to refer you - and I don't think you need to turn to it - but I am going to read to you an issue raised by the Ministry of the Environment at the scoping session in relation to Panel No. 10, and it is in relation to paragraph 23 of Mr. Greenwood's paper and it states:

"Conclusions considering full-tree harvests are more tentative..."

This is quoting from Mr. Greenwood, and perhaps I can give you the page reference of that. The bottom of 226 and over on to the top of 227.

MR. FREIDIN: I am sorry. I am sorry, Mr. Chairman. The quote is from paragraph 23 of the

executive summary and that executive summary states -- that is the executive summary for Panel No. 10.

THE CHAIRMAN: I don't have it.

MR FREIDIN: All right. Well, then I will read it. I don't think we will have a problem. It is at page 50 of 416A. It is in the big green book.

MR. MARTEL: What page is that, Mr. Armson -- or Mr. Freidin, what page?

MR. FREIDIN: Page 50.

THE CHAIRMAN: Are you talking the September one or the --

MRS. KOVEN: November 6th.

MR. FREIDIN: It doesn't matter, the paragraph hasn't changed.

THE CHAIRMAN: Okay.

MR. FREIDIN: So if you look at page 50 of Exhibit 416A and you go to paragraph 23 and you go five lines up from the bottom of the right-hand side where it says: Conclusions...

Do you have that, Mr. Chairman?

THE CHAIRMAN: Yes.

MR. FREIDIN: Okay. So what the Ministry of the Environment did is they quoted that, they said:

"Conclusions considering full-tree harvests are more tentative but are in

general agreement that given rationale management for a site, natural inputs of nutrients will balance increased exports."

And the question that the Ministry of the Environment asked was:

"In the context of this statement, what in specific terms constitutes rationale management."

Q. And I pose that question to you, Mr. Armson.

A. The rationale management would take into account (a) the site conditions that pertain - and I think I have explained what particular attributes of that one would look at - they would also take into account the choice of species and the rotation for that species, and in so doing, they would be looking at the regeneration, the numbers, not only the species but the manner in which the regeneration was being carried out, how that was undertaken.

So that if there were a concern, for example, for the forest floor the nutrients that were in that area, then there would be a concern that that was any disruption or particularly destruction of it would be minimized if not prevented entirely. If there

were the manner in which there could be additions made or allowing regrowth to occur then this would be a factor.

So those things, those would be what would constitute, I think, rationale management decisions.

Q. Thank you. Are there advantages to full-tree harvesting that will be spoken to by Mr. Oldford?

A. Yes, there are. Would you like me to indicate some of them?

Q. I think he is in Sault Ste. Marie and I don't think he will scream too loudly.

A. Well, one of the most obvious ones is that by taking off much of the slash, a large part of it, it makes it much easier to prepare, in terms of site preparation, and it also makes it much easier if artificial regeneration, particularly planting, is to be carried out for the planters to operate in that cut-over. That is probably the most obvious advantage.

In terms of the harvesting itself, that is the actual drawing off of the wood, full-tree harvesting results in a much more complete utilization of the standing timber than either shortwood or even tree-length because you are pulling out the entire

amount of the tree and making -- utilizing everything you have pulled out.

Shortwood harvesting is probably the least efficient in utilizing the forest or the trees in the forest.

So there are two reasons, one silvicultural, if you will, relating to setting in place of a new stand, and the other which is very immediate and relates to the harvesting itself.

Q. Now, recognizing that this area of full-tree harvesting is a matter of some discussion and, perhaps notwithstanding your comment to the question from the Chairman about what areas should or shouldn't be studied in terms of this nutrient concern, is the Ministry in any way addressing this lack of definitive conclusions on this subject?

A. Yes. The Ministry has indicated - and perhaps I might go back, Mr. Chairman. Within the province there is an Ontario Forestry Research Committee in which there is representation from both the Ministry -- or from the Ministry, from the industry and from the research establishments within the province dealing with forestry. And that committee is a Committee that establishes priorities for forest research which then may be undertaken by one or more

research institutions.

And a letter has been sent to the Ministry's representative, that is Mr. Drysdale who is the general manager of the Ontario Tree Improvement and Forest Biomass Institute which is the forest research entity of the Ministry in terms of -- and asking him to bring this concern for the harvesting and removal of nutrients, particularly as it relates to both the removal of nutrients and especially basic nutrients, calcium and magnesium, and what happens. And here we come to the fluxes, what happens to those following removal and within the soil, what happens to that particularly in terms of the movement of thoseions not only into new vegetation, but also in the flow of water and obviously, therefore, into the water system of the particular area in which it is carried out.

So it is concentrating really on the fluxes and the movements which, as I said, is a concern expressed by many scientists. So that letter is being sent to Mr. Drysdale.

Q. Now, Mr. Armson, I believe you are referring to a letter dated January the 13th, 1989 from Mr. Douglas, Director of Planning and Environmental Assessment Branch to Mr. D. - as in David - P. Drysdale who is general manager of the

Ontario Tree Improvement and Forest Biomass Institute; is that correct?

A. That is correct.

MR. FREIDIN: Mr. Chairman, I would like to file that as an exhibit, please.

THE CHAIRMAN: Exhibit 417.

---EXHIBIT NO. 417: Letter dated January 13th, 1989 from Mr. Douglas, Planning and Environmental Assessment Branch, to Mr. D.P. Drysdale, General Manager, Ontario Tree Improvement and Forest Biomass Institute.

MR. FREIDIN: Mr. Chairman, the reason this letter, or this copy doesn't have any letterhead on it, it is that a copy -- an actual copy we couldn't put our hands on it today. I had it, I just couldn't put my hands on it. I don't think there is any magic in the letterhead not being there, but just if anybody is wondering.

THE CHAIRMAN: You didn't just write the letter today?

MR. FREIDIN: No, sir. I am not too sure I said -- if I didn't say January the 13th, 1989, I may have said '88, I don't remember. It is January the 13th, '89.

MS. SEABORN: Maybe Mr. Freidin can just file the carbon copy of the original that actually went

out?

MR. FREIDIN: Yes.

MS. SEABORN: Until he has an opportunity to find it, just so the record is complete.

MR. FREIDIN: I lose the paper war from time to time, Mr. Chairman.

Q. And, Mr. Armson, do you have a copy of Exhibit 5A?

A. Yes, I do now.

Q. And can you advise, Mr. Armson, was the research referred to the January 13th, '89 letter Exhibit 417 the subject of some discussion between the Ministry of Natural Resources and the Ministry of the Environment and, in fact, an agreement between those two ministries?

A. I believe that was the case.

Q. And if you could turn, please, to Attachment No. 3 of that particular document, of Exhibit 5A.

A. Yes, I have Attachment 3.

Q. It is entitled: Timber Management and Water Quality.

THE CHAIRMAN: Mr. Mander has gone to get our copy, we don't have it.

MR. FREIDIN: I was going to have the

witness read about six lines from it.

THE CHAIRMAN: All right. You might as well go ahead and read it in.

Q. Okay. So under the heading it says: this attachment is: Timber Management and Water Quality: Results of MNR/MOE discussions March, 1988 and the heading is: Timber Removal from Areas of Low Base Cations and Nutrients.

Perhaps, Mr. Armson, you can read what it says.

A. Yes.

"The understanding of these potential effects..."

That is from the timber removal relating to areas of low base cations and nutrients:

"...of these effects is insufficient to warrant a change in operational procedure at this time. MNR will approach the Canadian Forestry Service with the aim of developing a study to assess the effect of tree biomass removal on future regeneration growth and success. This study will be linked to the proposed Water Quality-Fisheries Monitoring Program jointly developed by MNR and

MOE."

Q. And does that particular agreement refer to the full-tree harvesting method?

A. That is correct, that is my understanding.

Q. All right. And this particular research which is being referred to in this document and in Exhibit 417 would also provide information in relation to the acidification of soils?

A. That is correct.

Q. And it would deal with also the movement of acidic solutions within soils?

A. That is correct.

Q. And could you advise me whether information which would be obtained through a study such as the one which is the subject matter of Exhibit 417, would that provide information that would be required in order to assess increased acidity in soil, if it occurs, and the movement of the same through groundwater into the aquatic environment?

A. That is the intent, and it would also as well as the acidity, assess the levels of other nutrients.

THE CHAIRMAN: Leading question.

MS. SWENARCHUK: Mr. Chairman, not only a

leading question, but I believe the form of the question I think is extremely vague.

If the research has been devised, could we see it? If it has not been devised, then research in this general area undoubtedly could be designed to study any number of affects. But I think what would be useful would be for us to see, if finally in January of '89, there is some follow-up to March of '88 and if there is any action from the proposal.

MR. FREIDIN: There is no response, I don't believe, to date from the Ontario Forestry Research Council.

Q. Is that correct?

A. No, the committee -- I do not believe -- I can't be positive, but I do not believe that the committee has met since January the 13th.

Q. What does this group do with proposals like this? I understand this goes to the Ontario Forestry Research Council?

A. Mr. Drysdale would bring the letter and the proposal forward to the council -- to the committee which, as I say, has representation from all -- from the research establishments; federal, provincial, and the universities. And at that time they would consider this proposal in the light -- I

mean, there are a number of actions that could be taken.

The development of the research proposal could be delegated to one or the other, or there could be decision to, if you like, parcel out various components of it in relation to various different research bodies and institutions relating to their expertise facilities and so on that were available at each. There are any number of things that could happen.

MS. SWENARCHUK: I would suggest, Mr. Chairman, that it would be a much greater utility for the Board and the other parties here for the Ministry to inform us all what the proposed research in this area would be. As to the process by which it gets divvied out and is done or not done, that is speculative -- my friend's questions are also extremely speculative as to what it could turn up.

But I don't really believe that is of any particular value to us. I think it is very important though to know exactly what, if anything, the Ministry is proposing to do itself or assure is done in this area.

THE CHAIRMAN: Plus the fact it might be of some value, Mr. Freidin, if you could indicate on

behalf of the Ministry what would happen if the research proposal put forward to the council was turned right down or they didn't have the resources or they didn't want to proceed with it, what that would do to the agreement between MOE and MNR as set out in 5A which, unfortunately, we still don't have in front of us.

MR. FREIDIN: I have heard all the questions and I will address all the questions. I can't do it right now.

THE CHAIRMAN: Okay. As far as the leading nature of the questions, Ms. Swenarchuk, I realize they are a bit leading, but this particular witness I think can handle that type of question in the interest of expediting this part of the evidence.

MS. SWENARCHUK: I didn't raise the leading nature, I merely raised the speculative nature.

THE CHAIRMAN: Okay.

MR. FREIDIN: Q. Okay. Mr. Armson, if we could move on to an area which is referred to in Mr. Greenwood's paper entitled: Accelerated Nutrient Release. And I believe that there has been partial or full answers to perhaps some of the questions that I have asked - but to put things into context, Mr. Chairman, I intend to sort of repeat some of those

questions - and, Mr. Armson, if you have dealt with it perhaps you could just indicate generally where you had dealt with it, what you had said and we will just move on.

Does the activity of the harvest affect the nutrient cycle in any way other than removal of nutrients because of biomass removal as you have described?

A. Yes. And, again, the most immediate effect other than removal is to expose the forest floor, surface of the soil to increased temperature by solar radiation and by removing much of the vegetation that has been exacting water during the frost-free season and transpiring it - and I will be talking about the water cycle later on - there is normally an increased supply of moisture in the surface soil layer and, therefore, as a result of increased temperature and moisture, decomposition usually occurs at a greater rate following removal.

Q. And could you advise whether this accelerated nutrient release is positive or negative in terms of site productivity?

A. This would be viewed as positive.

Q. And I believe you have explained the positive nature of the nutrients being provided through

this more rapid decomposition?

A. Yes, I believe.

Q. Are there any potential negative effects resulting from the accelerated release of nutrients?

A. Yes. The decomposition and rendering of them more available. If they are not then absorbed within either the soil system or by new growth of vegetation, some of the elements may be lost in the movement -- downward movement of water through the soil and will then go to join the groundwater in streams and lakes and so on.

Q. All right. And when it goes into the ground and moves off towards streams and lakes and that sort of thing - well, whether it gets to lakes or streams - if it moves off the site in the soil, what is that referred to?

A. It is referred to as a loss, it is no longer available to the vegetation and moves out into another area.

Q. All right. Through groundwater?

A. Through groundwater, yes.

Q. As opposed to what other kinds of water?

A. Well, the over movement of water that

we normally think of is runoff which typically we think of as surface runoff, but if there is a complete forest floor, that is usually minimal to negligible.

Q. But you can have a loss of nutrients--

A. You can have a loss through surface --

Q. --through either ways?

A. Yes, that's correct.

Q. And at the risk of being repetitive, is the potentially negative effect that you have referred to through either of the two mechanisms; surface runoff or through groundwater, one which is likely to occur in a manner that unacceptable environmental effects will occur to the forest estate?

A. In the area of the undertaking, I am not aware of where it would be unacceptable.

Q. And by the forest estate, what do you understand that to mean?

A. I am referring to the boreal and Great Lakes forests of the area of the undertaking.

Q. And what particular part of that environment are you concerned about, or are you addressing when you say --

A. Well, I am not addressing the water

system at all, the streams and the lakes and so on.

Q. Does your answer address...

A. It only addresses the land base in that area.

Q. And is site productivity included in that?

A. Yes.

THE CHAIRMAN: What paragraph was that of Exhibit 5A that we were dealing with?

MR. FREIDIN: 5A? Oh, when we did 5A?

THE CHAIRMAN: Yes. We just got it.

MR. FREIDIN: I am sorry, it was Attachment No. 3 - I don't think the pages are numbered - and it is the very first paragraph.

THE CHAIRMAN: Thank you.

MR. FREIDIN: Q. And can you advise, Mr. Armson, whether there has been any work done in Ontario which supports your evidence that potential negative effects of accelerated release of nutrients on the forest estate are not significant?

A. I can't think of any studies. There are studies that have monitored the movement of elements into the water system and concluded that the amount that has been moved, obviously following logging, clearcut logging - this is a paper by

Nicholson, et al - that the amounts that were moved in, which may or may not be of significance in the water system - I can't address that - were insignificant in relation to the amounts that were in the forest -- the forest land part of the system.

So, in that sense, there has been a study, that was in northwestern Ontario.

THE CHAIRMAN: But they wouldn't be moving necessarily?

MR. ARMSON: Well, they were really looking at what came into the water system.

THE CHAIRMAN: As a result of cutting?

MR. ARMSON: As a result of cutting and then said: Well, if we track that back to the levels, the pool sizes and nutrients that were on the land base the amount we are measuring as an increase in the water when we aggregate it back is really a very small, small portion.

THE CHAIRMAN: But the point is: If you didn't clearcut at all--

MR. ARMSON: You would not have had that amount of water.

THE CHAIRMAN: --it wouldn't be moving?

MR. ARMSON: That's right. Correct.

MR. FREIDIN: Q. And in terms of

nutrients leaving a site through groundwater, would phosphorus be one of the nutrients which would be included in that?

A. Phosphorus would be one of them, yes.

Q. Would nitrates be one?

A. Nitrogen in the form of nitrates, yes.

Q. Thank you. Mr. Armson, you have spoken about nutrient loss due to removal of biomass and you have spoken about accelerated release of nutrients after harvest, and you have indicated that individually they do not result in a concern re: loss of productivity; is that correct?

A. That's correct.

Q. Now, there are other timber management activities that can occur on this hypothetical site, if you will, other than harvest.

And are you able to provide any opinion as to whether the potential effects of harvest in combination with effects that subsequent timber management activities such as site preparation and tending will have? Will the combination of those activities cause your answer to change; is really what I am asking?

A. No. They would in fact, if anything,

increase the positive side. That is, the site preparation, whether it be a mechanical site preparation which would -- depending on the equipment and the way it is employed, would tend to rip some part of the forest floor, not to discard, would tend to increase the rate of decomposition.

And tending, particularly by the removal of existing stems as in pre-commericial thinning, is in effect again a putting down of nutrients onto the ground surface again which can be decomposed and recycled.

Q. Thank you. And can you advise me: Does the scenario that you have described I guess a number of times in your evidence of the areas of southern Ontario which at one time were blowsands, have any relevance to this particular topic or the question I just asked you?

A. Well, only to the degree that they provide, if you like, at one end of the spectrum almost -- the most infertile type of condition that you could have to start with in terms of establishing a new forest as compared to what we have within the area of the undertaking.

Q. Mr. Armson, I would like to move on and ask you a few questions about acidification of

soils.

And I understand that an increase in acidification of soils due to certain harvesting practices is a matter of recent discussion within the scientific community?

A. Yes, it has been a matter of discussion primarily because of the overall effects of acid precipitation within both -- well, northern hemisphere I guess and so on.

Q. Could you describe the discussions which have taken place?

A. Well, the discussions that have taken place are primarily to determine -- well, discussions and studies to determine to what degree acid precipitation has brought about any changes in the acidity of soils.

And once you look at that, you are also into looking at what changes in acidity may occur in a soil as a result of the natural processes independent of acid precipitation.

Q. Have any of the discussions revolved around the effects of harvesting?

A. There have been some discussions, I am not aware of any studies of any comprehensive nature, but there have been certainly discussions as to

whether - centered around primarily, whether the removal of nutrients in the harvest material, which does contain a considerable amount of the bases calcium and magnesium, whether that removal would in the short, medium and longer term result in a more acid soil condition following the harvest.

And from the studies that have been undertaken, there is no clear evidence one way or the other. But I would point out to the Board that there is a factor that immediately comes into place because once you have removed the material, if the site is then exposed, you begin to get the temperature and moisture relationships which bring about greater decomposition which tends to bring more bases into availability in the soil from that cause and it is very difficult to sort the two effects out.

Q. Okay. Now, you are throwing around probably I think a new phrase, brings into play these bases. And what I wanted to do was to ask you to explain sort of in general terms what acidification means, particularly in terms of the soil, and perhaps you could incorporate within that answer an explanation and significance of this reference to bases?

THE CHAIRMAN: Just a minute.

MS. SWENARCHUK: Mr. Chairman, I wonder

if at some point today or tomorrow, before the end of Mr. Armson's testimony, if he could perhaps specifically refer us to the studies that he is discussing?

MR. ARMSON: Yes, I would do that, Ms. Swenarchuk.

MR. FREIDIN: Q. All right. Do you want me to repeat the question, Mr. Armson?

A. Yes, you repeat the question.

Q. Okay. I would like you to explain what acidification means in terms of acidification of soils, and I would ask you in your explanation to also provide the Board with an explanation of what you mean by bases and the role that they play in this particular subject matter.

Sounds like an exam question, Professor.

A. By acidification, whether it be in a solution or in a solid mix, but we are referring to the soils here which is a combination of both, what we are referring to by acidification is an increase in the concentration of hydrogen ions in the solution as we measure it.

And, therefore, since the concentration of hydrogen ions is affected by, on the other side, the concentration of hydroxyl ions and these are associated

with bases - I am trying to be relatively clear here - we equate the more basic a soil, the more that you have basic elements such as and particularly calcium, magnesium, potassium, then the less acid the condition in which they occur.

The more -- the less you have of the bases, the more hydrogen ions you have and the more acid it is. And we measure the acidity in a scale which is the hydrogen ion concentration which is referred to in numerical values as the pH - that is the small p capital H - and all that is is a logarithm of the concentration of hydrogen ions.

Q. So the higher the pH...?

A. The higher the pH the less acid and lower the pH the more acid, and the point of neutrality is the number 7.

THE CHAIRMAN: How well those of us who own swimming pools know that number.

MR. FREIDIN: I never understand what happens when I throw all that money in the pool.

THE CHAIRMAN: It turns green and you shortly do thereafter.

MR. FREIDIN: Q. And I believe you indicated that when you harvest in the removal of the biomass you are having an effect on the absolute number

of base ions on the site?

A. That's correct.

Q. In which way?

A. You are removing -- you are reducing the total amount of -- I would rather put it calcium and magnesium in whatever form they occur on that site.

Q. Is there any offsetting mechanism in relation to that?

A. There are two offsetting mechanisms. One I have already referred to which is the process of decomposition. The other is the process of weathering of mineral materials within the soil which releases -- depending on the nature of the geological materials, which releases elements such as bases of calcium and magnesium, and some minerals have more than others of those elements.

So this is part of the dynamics and the fluxes are replenished.

Q. Do soil scientists categorize soils as acid or base?

A. Yes.

Q. Why?

A. Because the acidity or alkalinity or basic nature of the soil can be linked to many other processes within the soil and the activities of many

kinds of organisms and their related processes.

There are certain organisms, for example, that thrive very well in acid soils, others that are very intolerant of acid conditions and so on.

So that when one knows the acidity or alkalinity - and in soil science we refer to it as the pH of the soil - then it conveys to a soil scientist a certain set of other -- not necessarily fixed conditions, but it gives them a sense of what other properties that soil may have, or certain other properties that soil may have.

Q. And, Mr. Armson, are soils in the area of the undertaking acid or base to start with?

A. The vast majority are acid.

Q. And, in your view, does that have any significance regarding this discussion or concern regarding the potential increase or decrease in acidity in the soil as a result of harvest?

A. Well, we have ranges of acidity, but what it means is that the vegetation and the conditions under which the forests have existed and continue to exist is one of an acid state. That's the first point.

Therefore, in terms of an effect by any factor, man-controlled or other, and I have indicated that fires, the normal effect of a fire is to bring

about a rise in the pH and, therefore, somewhat less acidity, not necessarily becoming not acid at all, that is a transitory, it occurs and then the soil reverts to its original acidity. So it is just a given, let's put it that way.

Q. Now, I used a phrase in my question to you, I said: What if it was acid or base -- you know, are the soils in the area of the undertaking acid or base to start with, and what did you understand me to mean when I said 'to start with'?

A. That the soils of the forest as we enter upon them now, the natural state, are they acid or basic and my answer is acid.

Q. And were you visualizing a forest with pre-harvest or post-harvest?

A. Was pre-harvest.

Q. Theoretically is there a point at which soil would become too acidic?

A. Yes.

Q. Have you ever seen this occur, or do you have any reason to believe that it occurs in the area of the undertaking as a result of timber management activities in such a way that it gives rise to a concern?

A. No.

THE CHAIRMAN: Can acid precipitation or does it, where it exists, kill forests as well as lakes or cause substantial damage; do you know?

MR. ARMSON: There is no evidence - and I am drawing upon the plots and the measurements and monitoring that have been conducted by the Canadian Forestry Service and the Insect and Disease Group of that, and by the provincial Ministry of the Environment, the staff were concerned with monitoring, in particular, the effects of acid precipitation on maple. I think this is the area, Mr. McNaughton has been involved in that.

And I attended a meeting last November that dealt very specifically with this - as well as, incidentally, the effects in Quebec - and from that meeting it was quite clear from the evidence presented as a result of those monitoring studies that there is no measurable decline either in terms of growth -- certainly in terms of mortality in the sugar maple in the area largely south of the area of the undertaking, as a result, that can be attributed to acid precipitation. There is quite a voluminous set of reports dealing with that.

MR. MARTEL: Can you tell me what killed the white pine then from the Sudbury basin down?

MR. ARMSON: Some of the killing of the white pine was related - my understanding and I believe I have seen some of the evidence, although I couldn't give examples of this - would be from going back some decades now to the sulphur dioxide emissions from the smelting operation at Sudbury.

There has been damage and I have seen this, and a gentleman who used to be the head of the Phytotoxicology Section of the Ministry of the Environment was involved some years ago in a study of the effects of ozone damage on white pine in the same area, the Temagami area, and then closer in towards Sudbury.

And there has been periodically considerable needle damage and some mortality from that and certainly earlier on from sulphur dioxide.

But I am not aware of any white pine mortality currently other than what might be attributed to these periodic -- these periods of ozone intensity which no one is really quite sure of how it comes about.

MR. FREIDIN: Q. Now, Mr. Armson, if you increase the acidity of soil, is there any relationship between that increase and the potential for increased acidity of lakes and streams?

A. Yes, there is a potential there.

Q. And could you explain how -- could you explain that connection?

A. Well if, as a result of an activity whatever that may be, there is an increase in the hydrogen ions, therefore in the acidity of the soil, and those ions are moved through the soil in the moist water in the soil to the streams, rivers and lakes, then those ions will in fact cause increased acidity in those waters.

Q. Okay.

MR. FREIDIN: Mr. Chairman, I think that would be a convenient time for a break, if we are going to have an afternoon break.

THE CHAIRMAN: Good, I just ran out of ink. 20 minutes.

MR. FREIDIN: I can advise people that there is no chance of finishing today, and there is a chance of finishing tomorrow at the rate things are going.

---Recess taken at 3:20 p.m.

---Upon resuming at 3:47 p.m.

THE CHAIRMAN: Thank you.

MR. FREIDIN: Q. Okay. Mr. Armson, you can move on perhaps then to the next topic, the

hydrologic cycle. Can you in very simple terms explain what the hydrologic cycle is?

A. Yes. And if I may with the Board, I am going to refer to Figure 7 which is in the document -- the Panel 9 statement of evidence and I have an overhead and, if I may, I will use it to illustrate the cycle.

Q. That's Figure 7. Is that on page 27?

A. That is on page 27 of the document.

Q. And perhaps before you do that, Mr. Armson, are you going to be focusing in on certain parts of the cycle in your evidence, or are you going to be talking about all of it?

A. No, I am going to be focusing on certain parts.

In the document itself, it refers to the main components of the water cycle, but this is the land part of it. I am obviously - as you see in that figure - am not dealing with streams and rivers and lakes and oceans, which is another part of the cycle, but I am dealing with the land base component.

Q. And I understand you will be dealing with inputs?

A. I will be dealing with both inputs and losses in a somewhat analogous way that I dealt

with in terms of the nutrient cycle and I am going to explain -- as I said earlier, in many respects we are dealing here with fluxes rather than pools; the pools are the lakes and rivers and streams, they are out of it.

There is a certain amount of moisture that will be retained within the soil, but it is a dynamic quality rather than a static quality. If I could refer to the figure, in terms of the water cycle from forest land, the source -- the ultimate source is the precipitation. What then happens to that as it moves to the soil surface in a forested condition or where there is vegetation, and in the diagram I have attempted to show various degrees of vegetation in a schematic way because there are some differences.

Assuming liquid precipitation, then it will flow through. Some of that water will be retained, we say intercepted by the crown, it will coat the surface of the leaves and, in fact, some vegetation is physically a greater interceptor of water precipitation than others, also the intensity of the storm is a factor, the rainfall. I think anybody who has ever been out in the rain and sat under trees recognizes that.

But the water that is intercepted and

does not flow down, and normally it would move from the foliage or the tree, either a stemflow down the stem, which can be quite important, or as a dripping from the tree and going to the surface of the floor; what it does not move in that direction is evaporated back into the atmosphere.

The significance of this is that where you have a complete canopy - and here I am referring primarily to a tree canopy, but this could be -- where you have a complete canopy, especially a large one and low intensity rainfall, you can have very major amounts of canopy or crown interception and movement back into the atmosphere; so very little of that moisture moves through to the soil. And it is the high intent -- higher intensity storms that, in fact, move through the soil as throughfall.

This also is true if the precipitation is solid. If we have snowfall, then again depending upon the nature of the forest, species, the crown canopies, then you may or may not get greater or lesser interception.

And I think the Board is aware that interception of snowfall on certain kinds of trees, particularly evergreens, can be important in terms of wildlife winter habitat, intercepts it and in effect

forms sort of a snow cover. So the interception factor can be a key one in looking at the overall movement of precipitation, whether liquid or solid.

The throughfall or the stemflow then moves to the soil surface. If it is stemflow, it will then move down along the upper part of the root system at the ground surface and then moves along roots. And this is becoming increasingly an area of interest for many soil scientists because the amount of the stemflow -- it is as if you have water flowing along the outside of a pipe rather than the inside of a pipe.

The water movement is very rapid as it moves down the stem of the tree and then along the root system can be very rapid and, of course, it is going directly to the positions that it will be most advantageous and reabsorbed. So water that moves in stemflow is considered, if you like, very valuable water in terms of subsequent re-use by the trees.

Water that moves into the soil resulting from either dropping from the crowns or throughfall, through the crowns or in the openings, then moves into the soil and we refer to that as water of infiltration. And the key factor here is, again, we come back to rates. If the rate at which water is coming to the surface of the soil is greater than the rate at which

water can move into the soil, then it therefore follows that the water doesn't move and it has got to go somewhere else, and that is surface runoff.

Where the infiltration rate is greater than the rate at which water is received in the soil surface then, of course, you do not have runoff.

This is where the importance of the forest floor comes into play, because where you have the surface soil organic layers, the essentially fresh litter only partially decomposed at the surface, and then through -- that provides a system of pores or openings - and I have been referring to your question about the clay - this is one of the most open systems where you the water move through it very rapidly and into the mineral soil depending on what type of...

But that is why the forest floor minimizes and may, under most circumstances, in fact make surface runoff also negligible. It has this effect.

If the infiltration rate is in fact lower than the rate at which water is received with the forest floor, then the water then has to move either along the surface of the forest floor or within it.

What has happened then is water is moving through the organic surface layer. So that in itself

forms, if you like, an impediment to the movement of the water and minimizes the actual physical effect of erosion from surface runoff.

The net result of this is that we conclude that where we have complete forest floor cover - and they can vary in terms of both its nature structure and its thickness - by and large we have conditions which will minimize or almost render negligible surface runoff and certainly erosion. This is why we place a great deal of emphasis on that forest floor.

THE CHAIRMAN: And, Mr. Armson, you would normally expect that the usual theories concerning things water tables and recharge areas, et cetera, would remain the same?

MR. ARMSON: Oh yes, that is right. The hydrologic processes remain -- in fact, they are the same, but we are now applying them to a set of conditions which normally don't apply in the agricultural area in terms of arable soils because they are exposed for some part of the year. These have a permanent cover essentially.

When the water moves into the soil, the water of infiltration, it then can move - depending on topography - it can move literally -- and this is often

referred to as sub-surface runoff. I think most people wouldn't think of it as runoff, but it is referred technically often as that -- in that way and it eventually goes down and will join the drainage system. Or the water may move to deeper layers and join the groundwater, and this is I think what you are referring to, Mr. Chairman, as the normal processes.

Some of the water - and depending on the nature of the soil - will be retained within the soil body and there -- in other words, it doesn't move, it is held by physical forces within the soil, and there it will remain until it moves normally back up again as a result of absorption by tree groups or other vegetation and is then moved back out in terms of what we refer to as evapotranspiration.

If there were no vegetation there, then it would move by evaporation from the soil surface. But the largest loss is from evapotranspiration which is indeed very considerable.

In a very simplistic manner, you can view vegetation and particularly trees, particularly trees with deep roots as nothing more than biological pumps. Their main purpose in life seems to be pumping water out through their foliage.

Now, the key elements here; that is, the

precipitation, the input, the amount of the intensity of the water, the degree to which there is a vegetation covering all of the surface, all the way up, the degree to which during part of the year the vegetation has leaves which are transpiring water, losing water or if they have no leaves, as deciduous trees do not have in the late fall or in the early spring, then there are totally different relationships that will occur in terms of water conditions within the soil.

The temperature of the soil becomes an important factor. If there is a canopy, a full canopy from the spring and a coniferous covering, a complete coniferous covering in the area of the undertaking particularly, and you would have some snow, the ground is frozen to some degree, then any precipitation that comes down obviously is going to meet the different conditions here than if you have a hardwood stand with no foliage on it and the ground frozen.

So the elements of the type of vegetation, the season or condition of the soil, and the vegetation, vis-a-vis temperature, and the nature of the precipitation, all come into play and have to be considered.

When you are looking at -- if you are looking at balances, if you will, and more particularly

if you are looking for reasons why -- or what will happen when you interfere with one of these elements particularly, obviously in this case the vegetation. So these are the -- that, in terms of the water cycle, this introduces the key elements and that is what we are looking at.

Q. Now, I have a couple of questions while that is still up. When you referred to the subsurface flow, I think you then referred to groundwater?

A. Yes.

Q. And where is the groundwater shown on that?

A. Well, the groundwater -- this is the water flowing to depth and the groundwater would be in here. I think a natural...

Q. And so what's the distinction between subsurface flow and water leaving the site through groundwater?

A. Subsurface flow would move down through the soil laterally and will at some point enter into a part of the watershed, streams and so on.

Q. And groundwater, what does it do?

A. Groundwater, we refer to that as the water which is identified below the level of the water

tables. The water tables are the upper surface of that groundwater.

Q. And do you speak in terms of that groundwater moving away from the site?

A. The groundwater may be relatively static, or more often it is in fact also moving.

Q. The reason I am asking is that there was evidence that you gave in relation to the nutrient cycle and nutrients leaving the site through, I think I used the word term groundwater. I want to try to clarify whether that what was a proper use of the word.

A. They will leave the site either through the subsurface runoff or through the -- flow to the groundwater and out. They can leave either way.

Q. And I think you indicated it could leave in surface runoff as well where that occurs?

A. Surface runoff, yes.

Q. Okay. And you indicated that where in fact you had a complete forest floor, you wouldn't expect any surface runoff. Can you have some forest floor removal and not have surface runoff?

A. Yes.

Q. And --

A. Because if the forest floor is interrupted or disturbed in an intermittent way as, for

example, you will hear more in I believe Panel 11 about hatch scarification where in fact a piece of the forest floor is flipped - it's almost about that area, maybe a little bit larger than that - just flipped over and then six feet or two metres down the line there is another...

That has no effect in terms of increasing runoff because there is no channels there. Even when there are channels, as with some site preparation, if they run in certain ways there is minimal runoff, if any.

Q. And just one last question. When you were referring to the tree canopy - and I believe you were speaking to the role it plays in interception - you said the tree canopy -- you said, but it could be, and then you stopped in mid-sentence and changed thought.

I am just wondering, is there something else that acts in terms of interception that you wanted to refer to?

A. Well, the vegetation generally and, of course, the forest floor if it is totally exposed.

Q. Okay.

A. Particularly, if I might, the forest floor exposure -- if the surface is exposed, then again

the forest floor acts in absorbing the energy of impact of the precipitation and there again minimizes any erosion forces that may be present.

Q. Mr. Armson, in taking us through that particular figure, Figure 7 at page 27 of the witness statement, you have referred to certain -- or some of the factors which could affect, I guess, the inputs of water to the site and what factors might affect water leaving the site.

And I am just wondering if in fact you could perhaps summarize or list the factors that do affect inputs and outflows of water to the site?

A. Well, the most obvious one, and the one I have referred to is the vegetation. So there we are looking at the species I referred to, whether a species is a conifer, whether retaining its foliage or whether it is a deciduous species. So that will have an impact in terms of the period of the year during which evapotranspiration can take place.

Also, the species is important in terms of the root distribution because certain species which are shallow rooted - I believe again I referred very briefly to this in Panel 2, but I think it is more pertinent in this discussion - species which are shallow rooted will not be able to extract water, if

you will, for evapotranspiration even from a deep soil only to the degree that as they move water from the surface zone then there may be some upward movement.

Whereas a deep rooting species which will in fact tap the larger value of the soil will be able to retain a much larger amount of water. This is particularly important in soils and in areas where the recharge from the winter of the soil. Normally the forest soils in the area of the undertaking, virtually all of them, when they enter -- we come into the growing season those soils contain the maximum amount of water that a soil can contain.

We use a term -- we use a jargon, we say the soil is at field capacity. We mean, that's all it contains. If it had any more water, the water would run out the bottom. So that the spring -- and that is then entering --

THE CHAIRMAN: Why out the bottom, wouldn't it run off the top?

MR. ARMSON: No, it would go down to the groundwater, assuming you put rainfall in the top.

THE CHAIRMAN: Yes, and it absorbs all it can?

MR. ARMSON: Yes, but it would still --

THE CHAIRMAN: Wouldn't it pond

eventually?

MR. ARMSON: No. In most cases it will enter -- if we have a forest floor it will move into it and it is just like adding more water to a system of hydraulic tubes that are already essentially filled, it just comes out the bottom. As long as the rate that you add it doesn't exceed the rate at which it can flow out the bottom. If it does that, then you would have your situation.

THE CHAIRMAN: Okay.

MR. ARMSON: So the rootability or the root system - and that relates also back not only to species but to the stage of development, a very small - when we regenerate an area, either by natural means or by artificially, the root systems of those seedlings, those trees, new germinates are quite small relating to the total exploitable, and that was a term used by Dr. Timmer, that can be exploited by a root system.

So those are factors that enter into the utilization of water. The structure -- therefore, the structure and age of the stand becomes a consideration.

MR. FREIDIN: Q. And when you say structure of the stand at that time, what are you referring to?

A. We are talking about the physical

nature of the forest. If we look at a forest, particularly in the wintertime -- but any time of year, but especially when there are deciduous trees in it, you look at the stems and you look at the branches and the system, and then when those become coated with leaves you are looking at a physical structure.

Conifers have different structures, the spruce with its vertical stem and the lower sweeping branches; the hardwoods which tend to have branches that move up, that's what I am referring to.

That has an effect in terms of the distribution of water because, as I said, with interception, a crown that we associate with most hardwoods will tend to move more water down in stemflow than a spruce tree which has branches and needles which tend to flow -- physically move away from the stem. So we get differences in stemflow depending on species.

I wouldn't suggest it is a very significant point, but it does have some implications and the structure obviously changes with age. That I think is the key set of elements relating to the vegetation.

Q. I would assume then that the amount of vegetation would also be a factor?

A. The amount of vege -- whether there

is a complete canopy, a partial canopy. And certainly if one were dealing with a situation where you were comparing woody species, shrubs, trees as contrasted with grass vegetation, you have a totally different situation in terms of interception and movement into the soil.

The second one, and the most obvious feature besides the vegetation, is the soil itself and the conditions of the soil. And I believe I have put emphasis on the surface conditions, particularly the organic -- surface organic layers, the forest floor. That forest floor also may have quite different structures and compositions irrespective of its depth.

It is interesting, the surface runoff from a hard maple stand in the Great Lakes/St. Lawrence region would be far greater normally than it would be from a pine or a spruce fir stand in the same area. And the reason is that the litter of the hard maple leaves, in the fall and then after snow, lays compact. And if anyone has been out in the spring, in March after the last snow is going, those large maple leaves just act like shingles on a roof.

So that the final snow melt normally runs down those shingles and you get quite considerable surface runoff from that hardwood forest floor

condition as compared with the conifer one. It moves into the soil to a greater degree.

The nature of the inorganic soil, whether it be a coarse textured soil, a sandy soil, whether it be a fine-textured soil, the structure of the soil, whether there are cracks in it, structure that we find sometimes in clay, the degree to which roots penetrate, all affect the degree to which and rapidity with which water can move through the soil. So those are factors.

The slope, again, I think that's a self-evident condition. We note -- as foresters, we are very conscious of the fact that where we have soil conditions in stands that are located on slopes, relatively gentle slopes, but they don't have to be -- but two or three, four degree slopes, that there is a general movement of water through that soil and we recognize those slopes, and particularly the lower ends of them, as being usually much more productive areas than the upper levels of the slope because of that movement of water.

And finally, I think the other factor that I suggest, which is not indicated in that particular slide and; that is, whether there is the presence of a water table within the soil and more particularly within the rooting zone or slightly below

the rooting zone of the vegetation, and there we become interested -- in fact, we recognize water tables that are static which are not the common ones and those which are moving water tables which are very common in much of the forest area and extremely important in terms of the productivity of the forest stands that occur situated above them.

THE CHAIRMAN: Do you mean moving water table, in terms of where it locates itself or moving into the water?

MR. ARMSON: Moving the water itself, I am sorry, the water table does move too, but I am referring to the lateral movement of water.

MR. FREIDIN: Q. Is it the lateral movement of water that you said was important?

A. Yes. And this is -- I am talking of saturated flow here as distinct from unsaturated flow.

Q. Perhaps you could just expand on that and why that is significant?

A. Yes. If we have moving water within the soil; that is -- may I use the flip chart here - if we have a forest and a soil condition, or the trees are rooted and we have a water table, but the water beneath that water table is moving usually associated with these general slopes, then the one thing that

we -- this water is usually a low temperature water - within the ground is not warm it is usually cold - contains dissolved oxygen; the colder the water the more dissolved oxygen.

So that roots which require oxygen can in fact grow within conditions at the surface that may be saturated but where there is enough dissolved oxygen that they can get that, they don't to have air, in other words, in the soil. So that is one factor that allows the roots to retain their -- maintain their position of live roots actually within a part of the system that normally they couldn't because it is saturated.

Secondly, the water here is not pure water it contains dissolved elements. It is like a very weak nutrient solution. Some of the nutrients have come from the soils up here that are decomposing and so on. So these nutrients, the ones we have been talking about on various levels are moving through here and that is exactly what it is. I believe we sometimes refer to it as a natural hydroponic system.

The tree growth here, therefore, has developed and will develop with a condition in which - because of the lateral flow in relation to the evapotranspiration - where this is large and that is

relatively small in relation to it, and what you have is a dynamic system which can lead to growth.

And this is the most common situation that we have in the area of the undertaking where we have water tables. And we note on these areas usually quite productive stands.

The other situation with a water table would be one where you have -- I better use another page.

MR. FREIDIN: Do you want to mark that as an exhibit, Mr. Chairman, that particular one?

THE CHAIRMAN: Does anyone want it in?

MR. ARMSON: Number?

THE CHAIRMAN: Well, I think we can probably skip that one, not that your art isn't good.

MR. ARMSON: I have an overhead, Mr. Chairman, that deals with this in relation to harvesting activities. But perhaps, what I -- if we have another situation - I am deliberately drawing somewhat smaller trees - where we have a water table which is static, then we have something that is totally different because the water is sitting there, it may -- the water table level isn't a fixed one, it may rise vertically, but it is essentially a water table with low oxygen, it has very little influx of nutrients and

the root systems down in here, when they move into it, they normally will die after limited periods of saturation.

So these static water tables are ones that normally, for very small roots of tree growth, they are the more uncommon ones.

MR. FREIDIN: Q. In discussions in your evidence about nutrient cycles, you indicated that quite apart from the -- just one moment, please.

All right. So basically with a few exceptions in the evidence, what you have described is the hydrologic cycle in a non-disturbed state; is that correct?

A. That's correct.

Q. All right. I want to move to the hydrologic cycle where you have disturbance and I understand that perhaps somewhat a little differently than was done with the nutrient cycle, you will deal with the effect of disturbance from both natural causes and man-caused sort of at the same time?

A. Yes.

Q. You are not going to split them apart?

A. Yes, I will. That's right.

Q. And do natural disturbances and

man-made disturbances play a role in the hydrologic cycle or change the hydrologic cycle in a similar fashion, if you will, than as occurred in the nutrient cycle?

A. Yes, they do.

Q. And you described the factors which can influence the hydrologic cycle, you have just gone through that and listed them. Could you now describe the role that disturbance, both natural and man-made, play in changing the magnitude and, therefore, the influence that each of those factors plays in the hydrologic cycle?

A. Yes. And if I might, I would like to refer the Board to the Panel 10 statement of evidence and, in particular, page 234 on that and I would like with the Board's permission to use an overhead of that again.

First of all, just before I put the other overhead on, I would just like to draw the Board's attention to the fact that in terms of the element -- the amounts here, the evapotranspiration is a very large amount. So that anything that blocks off or results in a removal of that evapotranspiration; in other words, if there is no vegetation there, then given the same amount of precipitation, the water has

to go somewhere and the normal -- since it can't go back up again, it has to either go down the hill or through the soil and join the groundwater.

So the net effect of removing vegetation by whatever means, natural or artificial, is for the yield of water downstream to increase and the figure you see on page 234, I think it was, is a bringing together of results from a variety of areas not only in Canada, but also from a rather large set of data gathered from other countries. And that data from other countries is represented by the line on this graph.

The graph has a vertical axis in which is measured the increase in water yield, in this case in millimetres from zero to 400 millimetres. The horizontal axis from zero moves to the right to -- and measures the percentage of the reduction in forest cover.

Now, what you would expect is that as there is an increase in the reduction or, in fact, a decrease therefore in the amount of forest cover, you would expect there to be an increase in water yield. And the data from around a number of countries suggests that by this linear relationship the equation why it was put in there.

The dots on the figure are of two kinds; one which is coloured in the overhead red - and in the figure that you have is black it is coloured in - and the open circles. The closed circles or the red ones on the overhead are harvested areas, data for harvested areas in North America; and the open ones are data for wild areas from wild fire.

And what is interesting here is that the data from a wide variety of sources but some from Quebec, some from New Brunswick, some from Ontario all tend to lie under the curve that represents other countries. Although there is a general increase in water yield with decrease in forest cover, which is what we would expect, but that increase is, if you like, mitigated or minimal compared to the data for a number of other countries.

The only explanation that really makes sense is that although these may be areas that have been harvested - and note the harvested ones where there is a comparison, one from northwestern Ontario - I believe the harvested one is slightly less than the -- I would say it is of no great significance, less than the loss or the increase in yield from wild fire.

These are lower than what we might take as a more general average because of the fact that when

you harvest you still leave vegetation -- lesser -- lower understorey and even after a fire, particularly as I indicated in a fire in summertime when new vegetation can reestablished, any reestablished vegetation, albeit even low, as long as it has a complete canopy will tend to minimize the water yield increase.

So this is, I think, the kind of evidence, if you like, that we would take and then relate to conditions and say: Yes, there will be an increase in water yield, the magnitude will vary obviously but, in general, it is much less than we would associate with conditions in other countries. A number of the countries there were those of very little forest floor. I think the forest floor here is of considerable impact.

THE CHAIRMAN: Would loss of rain forests such as what they are talking about in Brazil sort of operate in the same way?

MR. ARMSON: In the rain forests - and I cannot speak from any personal knowledge - but from descriptions of the soils there and certainly from areas in subtropical -- other subtropical areas which I been in, there is virtually no forest floor. That is true also in some parts of southern Ontario, there is

virtually -- there is no forest floor. I will show the Board...

THE CHAIRMAN: Where you would lose the canopy completely.

MR. ARMSON: Where you lose the canopy, then it is own to precipitation.

THE CHAIRMAN: So it increases the water quantities?

MR. ARMSON: Yes, very much.

MR. MARTEL: And erosion?

MR. ARMSON: And erosion. Very much so. The two -- the impact of precipitation following removal of vegetation and erosion, the two things which we tie together. And as I say, I come back to the importance of that forest floor in all cases, and the existing vegetation that can be on a soil even after total harvesting of a forest cover.

MR. FREIDIN: Q. Mr. Osborn -- Mr. Osborn -- Mr. Armson...

MR. MARTEL: He doesn't see that.

MR. ARMSON: I know the lights are bad.

MR. FREIDIN: Q. Well, at least Mr. Armson's answers my questions. Mr. Armson, you have used the word water yield in this particular diagram. It says water yield increase in millimetres on the

vertical axis. What is water yield?

A. Well, water yield is the amount of water that is measured usually by some mechanical weir put in a streamflow at some point or a river that measures the water flowing to it, yes.

Q. And would the water yield that was measured in this case be water yield through both surface runoff and subsurface flow?

A. Well, it would be -- yes, this would be the increase in water yield that was measured at some point downstream--

Q. All right.

A. --from the area that had been affected by either harvesting or fire.

Q. This doesn't indicate what the percentages are?

A. No, it doesn't.

Q. And you have already given your evidence about surface flow and when you might or might not exact it?

A. That's correct.

Q. Okay. Before we turn that off, is there anything else that you wanted to say about that?

A. I think Dr. Osborn suggested, if we are talking about an increase in yield then it becomes

a question of the duration of the -- over which that -- some period of time over which that yield may be in effect. And we do have some information from an area in northwestern Ontario and this is...

Q. Page 235 of...?

A. Page 235 in the Panel 10 evidence and this is data -- these are data that were taken by Nicholson and his colleagues in an area where he was trying to measure what was not only the magnitude of the increase in water yield but over, in this case, a four-year term, although this is the point at which the study was not terminated but the measurements were made, what was in fact the duration.

And I will not speak in any great detail about water yield and so on and the quality of water, that I believe will be done by Dr. John Allin later on, but what is of interest here is that in terms of the water yield -- and in your figure the solid line is the uncut watershed, the control, and in the overhead that has been coloured red for ease of doing -- and the time period over which this has been measured during the season is from April through to just in the middle of September.

And the measurements are for an uncut watershed, as shown by the red line, for a one-year-old

clearcut watershed as shown by the hatched line, and for a four-year-old clearcut watershed in the same -- these are all in the same area as indicated by the dotted line. And then this is for this one period, this one season.

And what is obvious is that in all instances, including the control, there has been -- there has been a peak in water yield in the April to May. Well, that is what one would expect, that is a normal situation, the spring runoff.

And then as we progress through the season, these peaks will relate to times of precipitation and you will notice that the peaks for the uncut -- the controlled watershed are lower in all cases and that the highest peak in all cases is for the watershed that has been cut just the one -year; in other words, it hasn't been as much reestablishment although there may be some reestablishment of vegetation.

But what it does indicate is that as we progress through the season, although there are some differences they are -- in terms of absolute terms, we are not dealing with great magnitude in many of these instances, they go back to the intensity of precipitation. These only go up to four years.

It is my understanding that the water yields tend to come together, if you will, some time in the four or five to ten-year period. So that increase in water yield is a normal phenomenon after harvesting, and we would expect also after fire, and that increase will occur, but diminish over a period of time, and that is something of the order of four to ten years.

MRS. KOVEN: Excuse me, Mr. Armson. In terms of the concern about water table yield and the seasonal concern, I suppose people like farmers are mostly concerned with spring--

MR. ARMSON: That's right.

MS. KOVEN: --thaw and runoff and so forth. And, in fact, the volume increase for the spring is the highest increase on the chart?

MR. ARMSON: Is the highest, yes, and that is what we would -- and that is the normal condition even when we don't do anything.

MRS. KOVEN: Mm-hmm. But just the amount of that increase, I would think, would be problematic at that particular time of the year?

MR. ARMSON: Yes, it would be, yes. And that, of course, can vary. This study was done in an area of relatively shallow soils, so that the amount of water that would be held within the soil body itself

would probably be minimal; in other words, it wasn't there in deep soils.

MRS. KOVEN: And are you saying that within ten years that the water yields go back to some normal level?

MR. ARMSON: Yes, from the literature - and as I indicated, Dr. Allin will be speaking in more a detailed fashion about that timeframe and water yields and water quality - but certainly from the literature that is the gist -- and I am speaking of forest conditions that are either similar to or certainly not -- yes, very similar to ours.

MR. FREIDIN: I don't know who can turn the lights back on, but...

MR. MARTEL: Could I ask a question? Do forests prevent flooding or did I -- I think I read in the documentation that it doesn't, but the impression most people have is that forest cover would prevent flooding in the spring.

MR. ARMSON: No, let me turn it around, Mr. Martel. Flooding can occur where there are forests.

MR. MARTEL: Okay.

MR. ARMSON: But where you have minimal vegetation, where you insert a forest into it, you will

reduce the level of flooding because you are doing two things: You are putting an organic mat, if you like, on the soil by virtue of the litter, and you are also evapotranspiring water. So that when you have periods of peak precipitation, which is what give you the flood, you have a system in there which will tend to minimize it or buffer it.

But under extremely heavy precipitation, very high intensity rainfall, then even with forest conditions you can have floods. But during the growing season, during the frost-free season, particularly with vegetation with foliage on it, it moves water out, it dries out soil, so that when you do get rainfall it is going into a dry soil rather than a wet soil.

Does that answer your question?

MR. MARTEL: Yes, I guess -- I had read a number of documents referred to that.

MR. ARMSON: Well, it is true. I think there is a common perception that forests will prevent floods. They don't, they are -- forest conditions will minimize flooding where you have the precipitation that will cause flooding.

If I may. Parts of northern Ontario, natural forest conditions independent of harvesting, have been -- in fact, one of my earliest experiences

was up the Black River and there had been no cutting, nothing had happened up there except natural fire.

And I can vividly remember canoeing through stands of trees on an early May day because the river was in full flood and there had been -- there was nothing up there then, except a few trappers.

MR. FREIDIN: Q. Okay. Now, if one was concerned with potential for surface runoff, I am saying surface runoff, from a site to aquatic environment, what sort of condition would the site have to be in before you would get any amount of surface runoff that would cause concern?

A. The forest floor would have to be removed to a large degree in most of our conditions before you would get surface runoff, under the normal intensity of precipitation.

As I think I explained, if you had an extremely intense storm and the infiltration rate was low, then you are going to have some surface runoff.

Q. Now, on page 237 of Exhibit 416A there is reference to, I believe, desynchronization of snow melt, right in the middle of the page.

A. Yes, I see that.

Q. Can you just describe for us what that is and whether it is a positive or a negative

effect, or whether it has a potential for positive or negative effects?

A. Well, what we are talking about here -- what is being referred to here is the fact that when you remove vegetation, the amount of snow accumulation will be greatest, it is not in fact intercepted by the crown, so that in terms of the layout of the harvest and the degree of harvesting within an area - and this will depend again on species whether we are dealing with a deciduous species or a coniferous species - then the manner in which the snow melts and, therefore, adds to both the water moving into the soil and the water flowing off, but if the ground surface is frozen beneath the soil, then the water that melts has got to run off, it can't run into it.

So what is referred to here is the condition under which snow melt runoff would occur as related to the way you lay out the cut. If you lay out the cuts so that you minimize snow melt by the orientation of the cut, by the size of the cut, there are many ways in conditions where you want to either hold the snow, reduce the rate at which it melts there are, if you like, manners or ways of designing the cut that can do that.

Q. I would like to go back to your evidence which dealt with the factors which could affect the duration of increased water yield and you spoke about revegetation of the site.

Could you advise: Does soil depth play any part in terms of the duration that you might have increased water yield after a harvest?

A. Yes. As I indicated, in areas of shallow soil and particularly where there is a solid bedrock there is very little storage capacity within it, but one would have to distinguish very carefully between shallow soils with a very solid bedrock and those which have a fractured bedrock because where you have fractured bedrock you have almost a perfect condition for water to move through and down into the bedrock itself.

Q. Okay.

MR. FREIDIN: And, Mr. Chairman, I think Mr. Armson will be getting into a more interesting, perhaps, discussion of the different types of soils probably tomorrow, but one last question in relation to duration.

THE CHAIRMAN: Is that suggesting that it is not interesting today?

MR. FREIDIN: No, it is not. It should

be more interesting tomorrow, that is all.

Q. The type and intensity of harvest; does that play any role in the duration of increased water yield?

A. Yes, very much so. Where, for example, we have a - I believe the Board is aware of the term shelterwood as a form of cutting - where in fact there is a first cut into a stand, this is a type of cutting that is very -- used commonly in white pine in the Great Lakes/St. Lawrence region, again snowbelt area, where that form of shelterwood harvest system is used, then there is in fact, because of the canopy, a shading and retention of the snow so that it melts more slowly.

I think anyone who has been in conifer forests recognizes that that is the last place for the snow to go. So that, in fact, one can regulate to a degree - not completely - by that form of shelterwood cutting in certain areas, the rate at which there will be snow melt and, therefore, down through the system and increase in water yield. You can minimize it, you can't reduce it totally.

This is -- I have referred to this earlier in terms of the lay out of the cut. Cuts which are opened up on south-facing slopes are obviously

going to have a much greater rate of snow melt on certain days than ones on -- north slopes will retain the snow and, therefore, if you have in fact a larger cut size on a north-facing slope, in terms of just straight water yield, you are still going to minimize the amount of increase in water yield under those conditions.

So those are the sorts of things that we would...

Q. All right. And your answer was directed towards a difference in terms of the duration of water yield based on what would occur in one spring. If I could--

A. Yes.

Q. --if I could just ask you whether the type and intensity of harvest; clearcut as opposed to selection cut, that sort of thing, and intensity of harvest would be a factor in terms of determining how long increased water yield after harvest might take place, and so I am thinking about over time.

A. Yes. Where there is a selection, where there is -- well, really what we are coming back to is the degree to which the forest cover is removed and the graph that I showed is really explicit here: How are you removing it according to a "selection

system or a shelterwood system or a clearcut system", really what you are doing is moving from the left-hand side to the right-hand side of that graph.

MR. FREIDIN: Mr. Chairman, it has been a long day, this would be a convenient place to break.

THE CHAIRMAN: Sounds good to us. Thanks very much.

I guess tomorrow we will start at 8:30 to try and get in a reasonable day and we will break at 1:30 or so in the afternoon.

Thank you.

MR. COSMAN: Mr. Chairman, just perhaps before we do, can we have an indication from MNR counsel as to whether or not we will be cross-examining some time late tomorrow or on Tuesday morning?

MR. FREIDIN: Do you want to?

MR. COSMAN: I am ready any time.

MR. FREIDIN: Okay. I would be surprised if we finished tomorrow.

THE CHAIRMAN: Thank you.

---Whereupon the hearing adjourned at 4:50 p.m., to be reconvened on Thursday, February 16th, 1989, commencing at 8:30 a.m.